SCIENTIFIC AMERICAN SUPPLEMENT No. 755

Scientific American Supplement, Vol. XXIX. No 755.
Scientific American, established 1845.

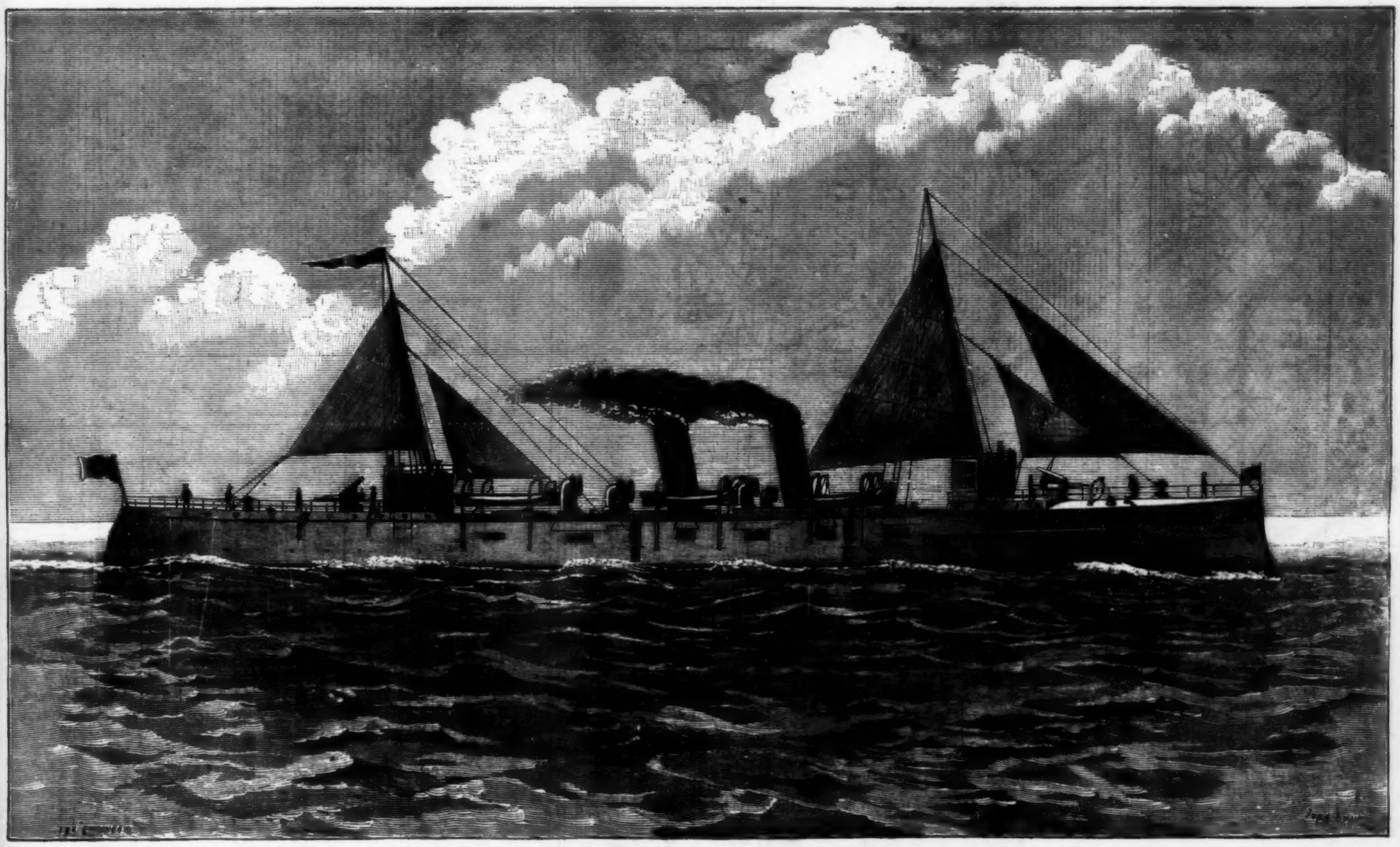
NEW YORK, JUNE 21, 1890.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

H. M. S. LATONA.

THE launch of the first cruiser embraced in the programme of the Naval Defense Act of last year took place at Barrow, May 22, from the yard of the Naval Construction and Armaments Company. The cruiser, which is one of the three being built and engined by this company for H. M. Government, was named Latona. She is one of the second class of cruisers, of which twenty-six are to be built. After the launch, the Latona was taken into the docks at Barrow, and placed under the 100 ton hydraulic crane, where she will receive her engines and boilers and general equipment.

The Latona is one of the new type of protected cruisers, and is of the following dimensions, viz.: 300 ft. long by 43 ft. beam, by 22 ft. 9 in. moulded depth, having a displacement of 3,400 tons on a mean draught of 16 ft. 6 in. Externally the vessel has a very smart appearance, having two funnels and two pole masts, with a light fore and aft rig; the hull throughout is built of steel, the stern, stern post, propeller brackets, rudder, etc., being of cast steel; the propelling machinery consists of two sets of triple expansion engines with cylinders 33½ in., 49 in., and 74 in. in diameter by 39 in. stroke, capable of developing over 9,000 indicated horse power with the boilers worked under moderate forced draught. They are of the light type adopted in modern war vessels, cast and wrought steel being largely introduced into their construction. The steam is supplied by five boilers, having an aggregate of 16,000 square feet of heating surface. The arrangement for forced draught is that known as the closed stokehold system, each stokehold being fitted with two powerful fans worked by separate engines for the supply of air. A distinctive feature of this cruiser is a steel protective deck extending fore and aft, the forward part running down with a long sweep to the ram of the vessel, of which it forms part. The transverse section of this structure is in the form of a flat deck, the crown of which rises about one foot above the water line at center of vessel, and slopes down toward the sides to a point about 4 ft. below the load line. On the sloping part the average thickness is 2 in., with a thickness of 1 in. on the crown. Under the protective deck are placed the engines and boilers, magazines, steering gear, and other vital parts of the ship. As, however, in the Latona vertical engines have been adopted instead of horizontal, as fitted in some of the former vessels of this type, the necessary protection for the parts of this projecting above the protective deck is obtained by fitting a belt of 5 in. steel armor with 7 in. of teak backing round the engine hatchway, between the protective and upper decks. The subdivision into numerous watertight compartments has been as usual in war ships fully carried out in the Latona. For the full extent of the engine and boiler space a complete inner bottom is fitted, the continuity of which is carried forward and aft by the watertight flats forming the magazines and store rooms on the ship. Alongside the engines and boilers amidship coal bunkers are also fitted, formed by longitudinal bulkheads extending to the upper deck, thereby affording additional protection to the machinery. Moreover, numerous transverse bulkheads are fitted, the hull under the upper deck being thus divided into about 100 watertight compartments. The greater part of the hull amidships under the protective deck is occupied by the machinery, there being two separate engine and boiler rooms. Aft of the engine rooms are the magazines for the supply of the after guns, as well as the steering gear, both hand and steam, fitted in two separate compartments. Forward of the machinery spaces are the magazines for the forward guns, and the various store rooms required for the ship. Above the protective deck aft are the cabins for the ship's officers, the part amidships being occupied by the coal bunkers, artificers' workshops, wash places, etc., while the part forward is entirely devoted to the crew. Under the poop are placed the cabins of the commander and principal officers, ward room, etc., the forecastle being taken up by the crew. The armament of the ship consists of two 6 in. breech-loading central pivot guns, one mounted on the poop and another on the forecastle; six quick-firing 4·7 in. central pivot guns, three on each broadside; eight quick-firing 6 pounder guns, four on each broadside, besides a 3 pounder Hotchkiss, and four five-barrel Nordenfelt guns mounted at suitable stations along the sides of the vessel. One 9 pounder gun for boat and field purposes is also secured on deck. In addition to these, there will be one aft and one on each broadside under front of poop. For controlling the ship in action, a conning tower of steel, 3 in. thick, is fitted on the after end of the forecastle inside, in which all the gear for manipulating the engines, steering gear, guns, etc., is placed. As regards the pumping arrangements, an elaborate system of piping is fitted, extending to every compartment, while the fire service and sanitary arrangements are on the same elaborate scale. A complete installation of electric lighting is also fitted, including three powerful search lights. The crew numbers 252 hands all told, for whose accommodation and comfort every care has been taken in the way of utilizing the living quarters to the best advantage.—*The Engineer.*



THE NEW BRITISH ARMORED CRUISER LATONA.

THE MARINE LOCOMOTIVE.

To the Editor of the Scientific American:

In the SUPPLEMENT to the SCIENTIFIC AMERICAN of March 8, of this year, I saw a short notice about a *Water Walker* which closely resembles in some of its chief parts an arrangement proposed by me some twenty years ago. In the SCIENTIFIC AMERICAN of April 26, 1873, you gave a sketch of my water locomotive and pronounced it "impracticable in a seaway."

Well, this water locomotive was not intended for a seaway, but for a canal. Since that time I have embodied the same ideas in two different types of vessels, one for a river and one for the sea at large. You will find drawings of them in a book I offer you with the present, entitled: "La Locomotive Marine: Etude sur le Transport Maritime a Grande Vitesse. Par A. Huet. Quatrieme edition, avec figures et deux planches. La Haye: Chez Gebl. Ten H. van Hanquehuysen, 1879."

In this book I have brought together, as far as I have been able to do, the numerous proposals made for adapting revolving drums to support and propel vessels. The first of these proposals was an American one, from the year 1826. I found it in a Dutch journal, but the American paper from which it was taken is unknown to me.

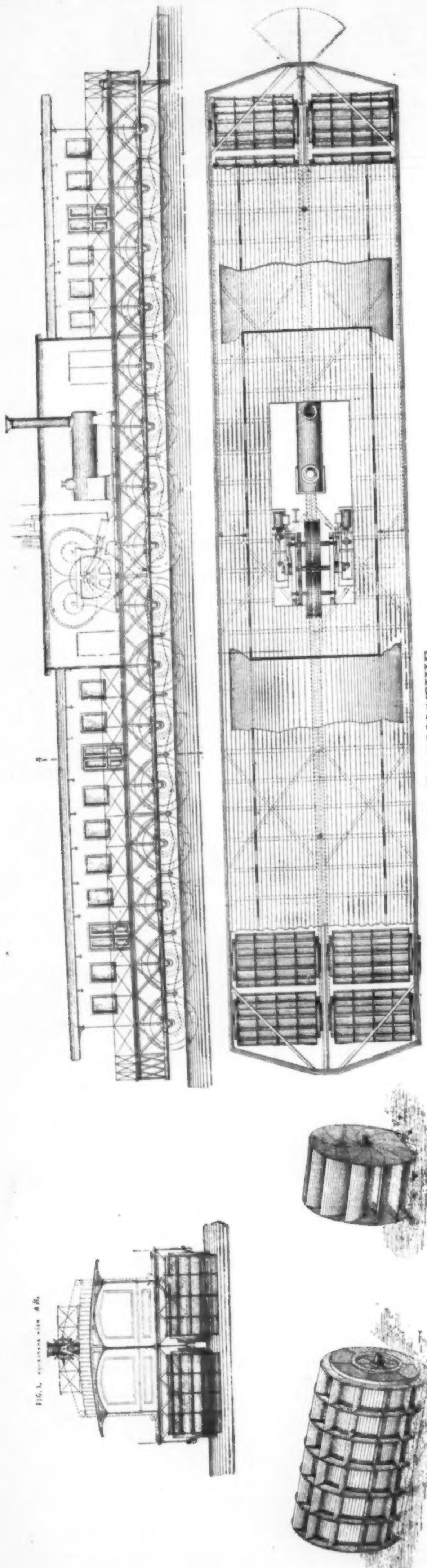
When I first occupied myself with this problem, in 1868, I thought my proposal original, but afterward I discovered that others had preceded me in this line of thought.

The problem is unsolved as yet because no trials on a large scale have been made; but it seems to have some vitality, because every now and then it is taken up by different persons.

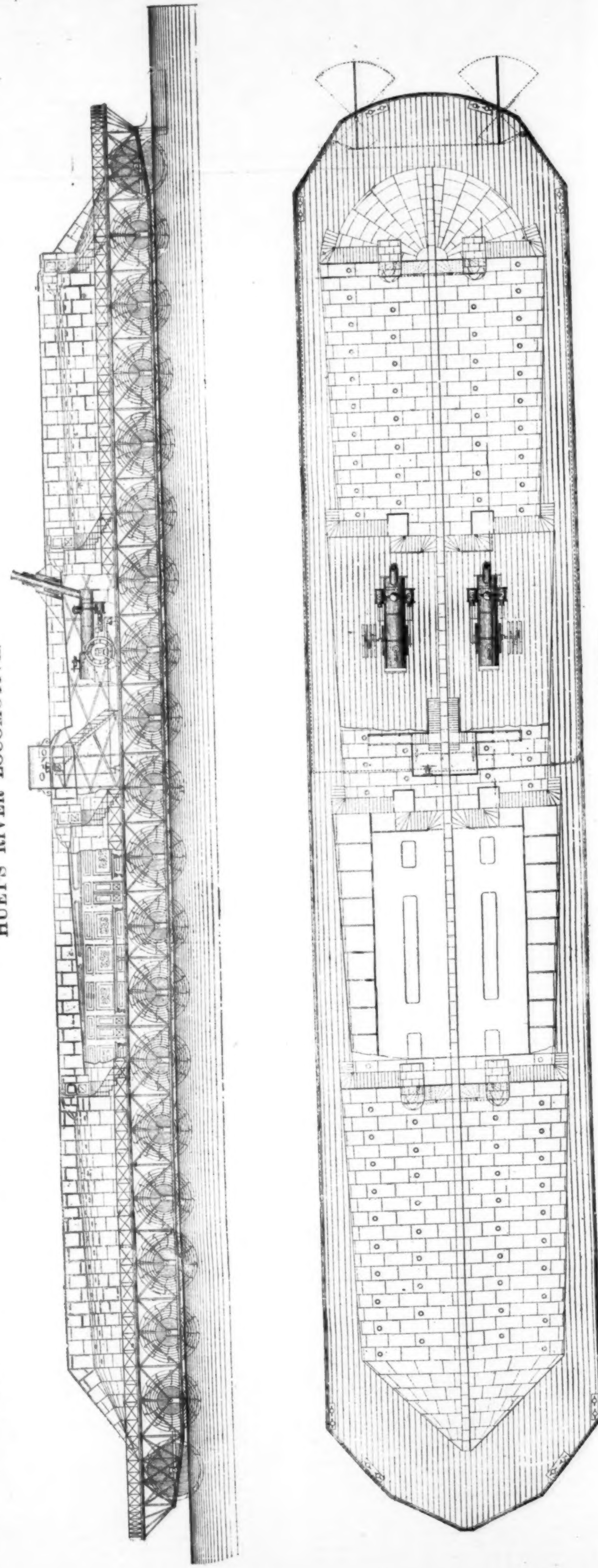
I have been very fiercely attacked on this subject, as you will find out by perusal of the book. But it must not be forgotten that Europe is not America, and that the judgment of the proposal, which was very unfavorable in my own country, was fairly counterweighed by the opinion of foreign European journals. You will easily find this out by looking in the said book.

Some trouble is of course always experienced when new proposals are made; but whatever may be the merits of the scheme, one thing is certain: that as yet it has not had a fair trial. Perhaps a notice about it in the columns of your widely spread journal may contribute in fixing the attention of other people and inducing well-moneyed people to give the fair trial which is wanted.

Will you have the kindness to insert this letter in an early number? I shall be much obliged. Reproductions



HUET'S RIVER LOCOMOTIVE.

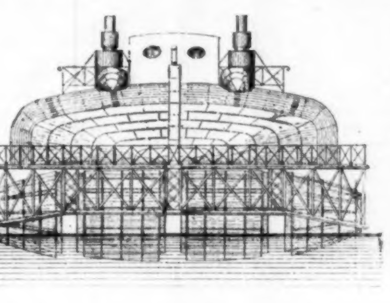


HUET'S OCEAN LOCOMOTIVE.

of the drawings in my book are of course freely permitted. A. HUET.

Delft, Netherlands, June, 1890.

[We have received the book referred to, which is a volume of 250 pages. In it we find plates of Mr. Huet's invention, which we herewith present. These seem to give a fair exhibit of the author's ideas in respect to



HUET'S OCEAN LOCOMOTIVE.

the construction of marine locomotives, and if any one desires to try the experiment on a large scale, as he suggests, now is the time. On the smooth waters of the Hudson River or the Rhine, such ships would look very well; but how they could stand the fierce waves of the Atlantic is a serious question.]

THE NEW YORK AND LONG ISLAND TUNNEL.

THE contemplated tunnel under the East River that is to connect the Long Island Railroad with the New York Central & Hudson River R.R. is an important and interesting project, some features of which we are enabled to present to our readers through the courtesy of the Chief Engineer, Mr. O. W. Barnes.

The tunnel is to start at a point on the Long Island shore beyond the Dutch Kills, pass under that inlet, and beneath Hayward and Oliver streets, Van Alst, East and Vernon avenues and West street, reaching the river at a point under the foot of Seventh street, five blocks above the present ferry slips of the Long Island Railroad. Before reaching this point it has come into and is running in direct alignment with the center of Forty-second street in New York. It passes under the river on a descending gradient of 1·25 per cent., or 66 ft. per mile, until it reaches a point 1,050 ft. from the New York shore. Here there is a level of 1,200 ft., with the bottom of the tunnel 120 ft. below mean high water mark, followed by a rising gradient of 1·2 per cent., or 63·36 ft. per mile. This brings the excavation to the surface at a point between Tenth and Eleventh avenues.

It is not the intention to disturb the streets of either city in any way by the construction. In Long Island City the portal and open works will be on private property acquired by the company or on the right of way of the Long Island Railroad. In New York the tunnel runs under Forty-second street to a point under Tenth avenue, where by curving northwardly the line deflects from the street in order to locate the portal on private property north of Forty-second street, through which it passes by an open cut to Eleventh avenue, making connections on the surface with the tracks of the New York Central a short distance north of Forty-third street, as shown in Fig. 2. A branch line from the main tunnel will deflect from the tangent of Forty-second street at a point 400 ft. west of the curb line of Tenth avenue. Curving from there to the left it will pass on to the private property south of Forty-second street, and will emerge from a portal and pass through the block in an open cut to and under Eleventh avenue by ing 50 ft. progress per week for each heading will give 400 ft. of excavated tunnel per week.

At Man of War Rock permanent pumping and ventilating works will be located for the drainage and ventilation of the tunnel. Under this point a sufficient sump well will be dug, into which all water from either end will flow, whence it will be lifted to the surface and poured into the river.

In driving the tunnel below the river the first heading will follow the grade line of the roadway, so that there will be a thickness of 50 feet of rock to resist the blasting needed in excavating the heading.

The roof of the completed tunnel will be 25 feet below the river bottom. This thickness is deemed safe in view of the fact that in excavating under the river bottom at Hell Gate, Gen. Newton's miners worked in some small areas within 8 ft. of the river bottom. No trouble is anticipated from cracks or fissures in this rock, as it is gneiss and very solid, so that it is not at all likely to be disturbed by the light blasts that will be put in to drop the roof work into the first heading. This naturally demonstrates, moreover, that the property owners along Forty-second street will never suspect that a tunnel is being run under their street.

In Long Island City the bed rock is farther from the

Fig. 3, shows the arrangements at the Grand Central Depot so clearly that no comment is necessary.

Electricity will be used in lighting the tunnel and the walls of the corridors, and pillars at the stations will be lined with white glazed brick to brighten the effect. It has also been proposed to use electric motors for hauling trains, but no decision has yet been made upon the matter.

The thickness of the rock over the roof of the tunnel below the street surfaces is as follows:

First avenue	114 ft.
Second avenue	118 "
Third avenue	97 "
Lexington avenue	95 "
Fourth avenue	98 "
Madison avenue	103 "
Fifth avenue	106 "
Sixth avenue	83 "
Seventh avenue	66 "
Eighth avenue	46 "
Ninth avenue	20 "
Tenth avenue	2 "

The total length of the tunnel is about 17,000 ft., and the cost is estimated at $1,000,000 per mile.

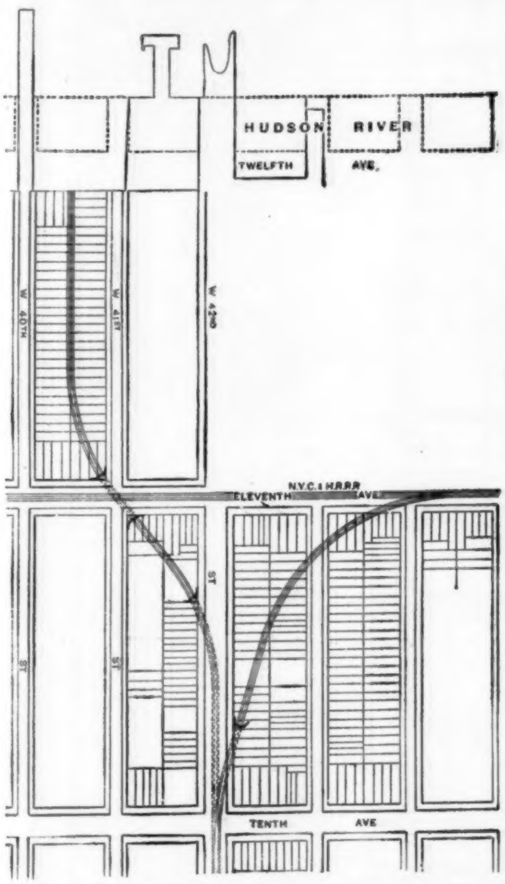


FIG. 2.—CONNECTIONS WITH THE NEW YORK CENTRAL AND HUDSON RIVER R.R.

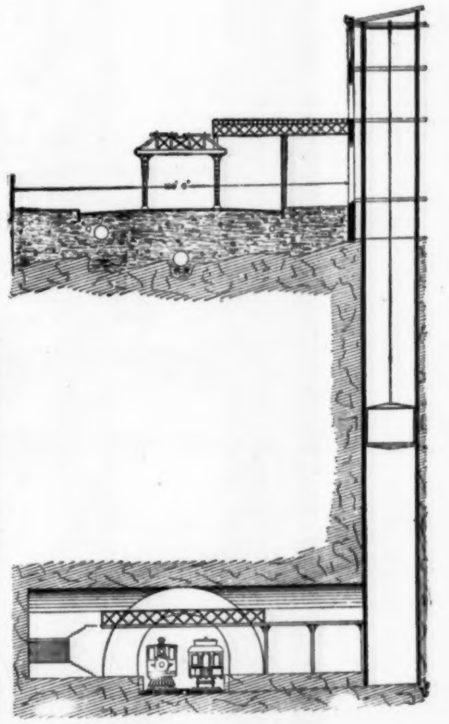


FIG. 3.—SKETCH SHOWING UNDERGROUND STATION AND ELEVATOR.

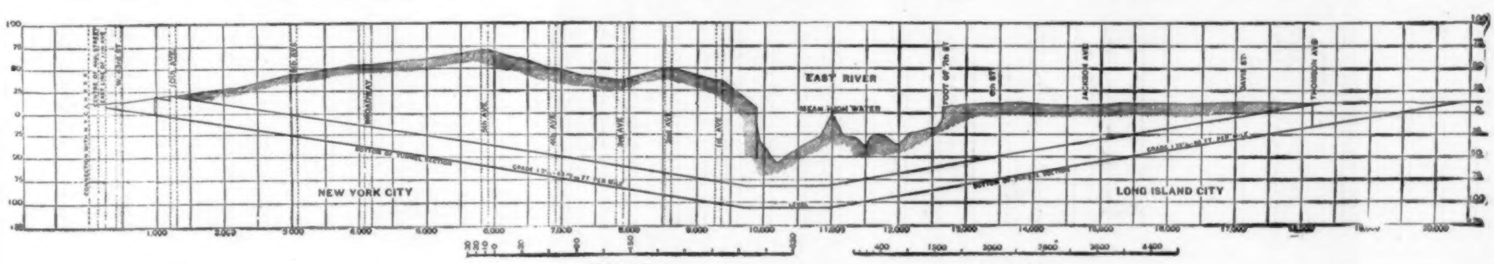


FIG. 1.—GENERAL PROFILE.

PROPOSED NEW YORK AND LONG ISLAND RAILROAD—TUNNEL AND CONNECTIONS.

an iron girder bridge, the ascending grade bringing the tunnel roadway to the surface in the present abattoir property in the block between Fortieth and Forty-first streets. Here the tracks will be extended to the North River, where there will be slips for receiving from transfer barges railroad cars from the railroads terminating on the west side of the Hudson River.

It will be noticed by reference to the profile, Fig. 1, that there is a reef in the East River, 1,120 ft. east of the New York shore. This is Man of War Rock, located 1,300 ft. south of Blackwell's Island, and is bare at low water. A coffer dam will be built on and about this rock and a shaft sunk to the bottom of the tunnel from which headings will be driven in each direction. As it is the intention to put in passenger elevators at the Grand Central Depot, shafts for these will be sunk at first and headings driven in both directions from this point also. Work will also be prosecuted from each end. It will be seen that there is every facility for rapid progress and the easy disposal of the debris. At the east end it will be hauled away by the Long Island Railroad, at the west end and the Grand Central Depot by cars on the New York Central, and at Man of War Rock by scows. Thus eight headings can be driven at one time; count-

surface, and the work will have to be prosecuted for a distance through gravel. In passing under the Dutch Kills a coffer dam will be built, the tunnel carried through in the open and arched over, filled in, and the waters allowed to ebb and flow as before.

It is the present intention to put in two elevators at the Grand Central Depot and one at the corner of Sixth avenue, though the latter has not been decided upon. The Grand Central elevators will have a capacity of 50 passengers each and come to the surface in the southeast corner of the present arrival station. The ventilating and other elevator shafts will be located as convenience and economy may dictate.

The arrangement of an underground station is indicated in Fig. 3. There will be a broad platform on either side close to the rails, opening back through Gothic arches cut in the lining rock into corridors 11 ft. 8 in. wide in the rear. These corridors and platforms are laid out 420 ft. long, but it is evident that they can be cut to any length that the necessities of the traffic may demand.

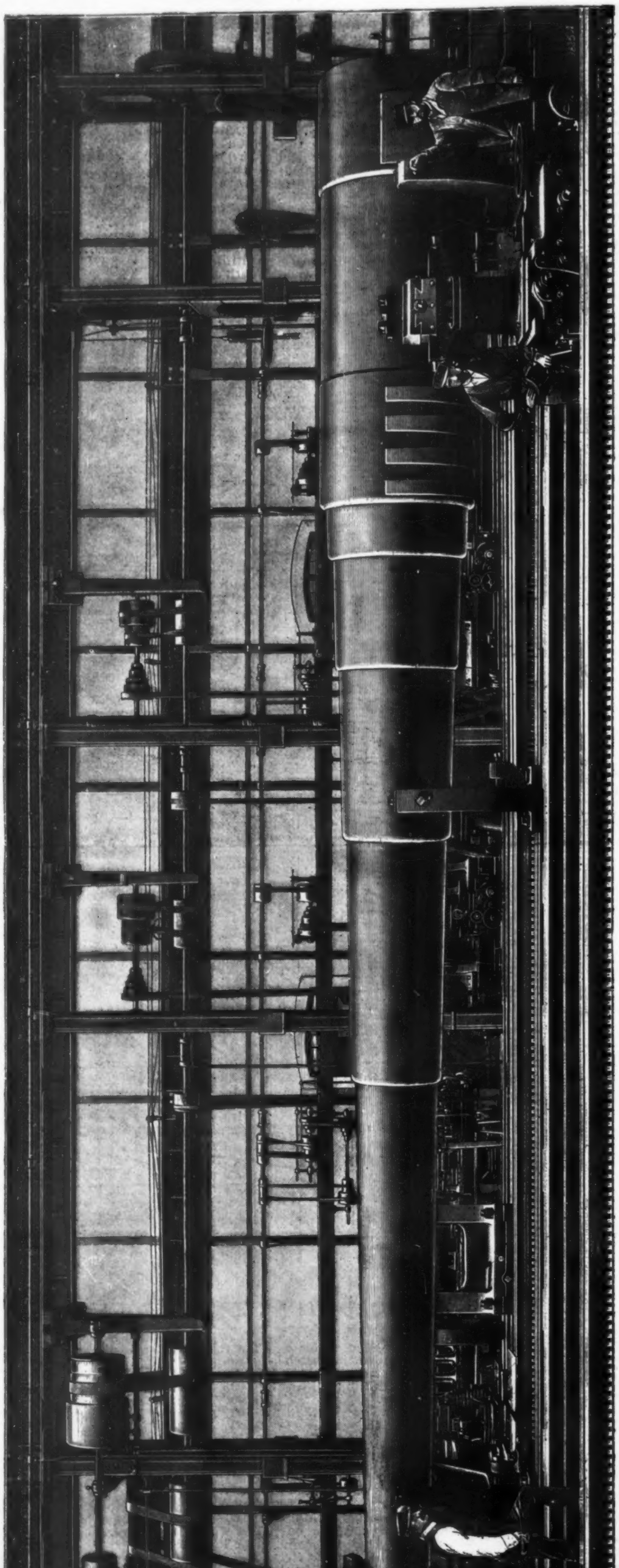
The tunnel itself is to be 26 ft. wide and 22 ft. 6 in. high, which will give ample head room for a man to stand with safety on the roof of the ordinary freight car.

The sectional engraving of the tunnel and elevator,

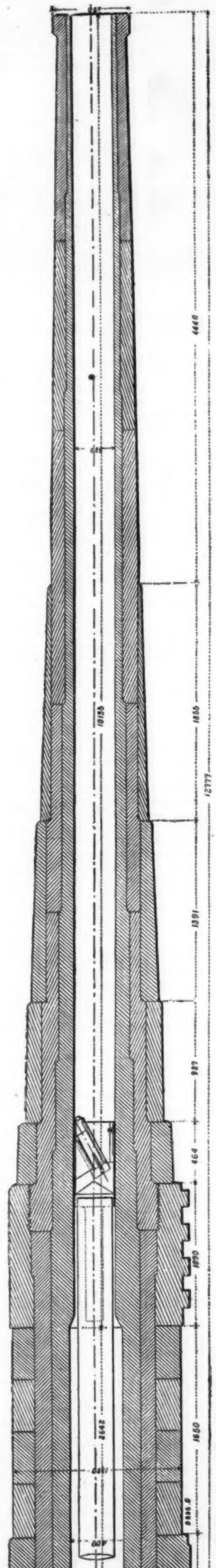
The following is an estimate of quantities:

550,000 cu. yds. tunnel rock excavation.
400,000 " earth excavation open cuts.
40,000 " masonry in walls.
75,000 " " " arches.
9,400 " shaft linings.
280,000 enameled brick.
1,500 cu. yds. enameled brick labor.
1,100 " jack arches.
535,000 lb. iron girders.
7,500 ft. piling.
1,000,000 ft. B. M. timber.
70,000 sq. ft. of street paving.
Ten elevators for 50 passengers each.
Five iron stairways.
Four station buildings.
24,800 lin. ft. of 20 in. drain pipe.
12 miles (90 lb.) steel rails for track and sidings.
Ventilating plant.
Bridge over 11th avenue at 43d street.
Buildings and pumping plant on Man of War Rock.

To all of which must be added the outside work of rebuilding sewers and changing the gas and water mains near the west end.—*Railroad Gazette.*



ONE HUNDRED TON GUN LATHE, AT THE GUN FACTORY OF THE FORGES ET CHANTIERS DE LA MEDITERRANEE, AT HAVRE.



SECTION OF 32 CENTIMETER 66 TON GUN FOR THE JAPANESE GOVERNMENT.

THE GUN FACTORY OF THE FORGES ET CHANTIERS AT HAVRE.

THE Forges et Chantiers Gun Factory at Havre offers a considerable contrast to the other manufacturing departments of the same company, which, with the exception of the ship yard and foundry, adjoin it. This part of the works is of much older date, and has, in fact, grown out of a comparatively small engineering works purchased by the company and gradually extended as necessity arose. Extensive as the machine shops now are, they are so crowded from end to end with work in progress of many kinds, and with the machines required for doing that work, that there is but little room for handling the great weights which have to be lifted. Probably before long this condition of things will be altered by reconstructing the works and extending them at the same time. A large amount of special labor has to be done at these, as in most other large French works, that is avoided in corresponding English establishments, in the manufacture of brass and iron fittings and numerous small parts which in England form the subject of special industries only partially known and followed in France. The boiler shop and foundry belonging to the works are very extensive, and in the latter all iron castings required by the company are produced, some of them of larger sizes, it is claimed, than can be made elsewhere in France. The machine shop contains a considerable number of English tools, among which is conspicuous an enormous lathe capable of taking on its face plate the largest gun carriages yet made by the company—those for the 66 ton guns built for the Japanese government. All the carriages and mountings are made in this shop, an undesirable arrangement, which will probably be altered before long, and this manufacture be converted into a separate department.

As there is a complete plant for finishing ordnance up to 100 tons weight, it may readily be imagined that a very large amount of space is absorbed for the heavier work, and that the arrangements for handling and transporting the guns must be very complete. The overhead cranes running from end to end of the central bay are of various capacities, and can be combined so as to deal with the heaviest loads required. Our engraving gives a good idea of one of the largest lathes with a 66 ton gun mounted on it. At the present time there are three of these great pieces of ordnance in the shop, one of them practically completed, and the other two far advanced. The time required for completing such a gun, supposing no unforeseen delay to occur, is fifteen months. Ranged in a row on the opposite side of the shop to that occupied by the lathes are the boring and rifling machines for the largest calibers, the last-named operation for the 66 ton guns just referred to occupying for each fifty days. Besides the various heavy machine tools required for the manufacture of guns of these large calibers and weights are a large number of others for making smaller natures; the main shop is not, however, employed for the lighter classes of ordnance. There are in all ten such lathes as that we illustrate capable of taking masses of steel up to 46 ft. in length and weighing 100 tons; and two rifling machines for similar calibers. For smaller sizes, there are twenty lathes taking in work from 20 ft. to 30 ft. in length, and weighing from 10 to 20 tons; two corresponding rifling machines complete this section of the plant. Of miscellaneous tools, for planing, screwing, and slotting, there are of course a large number. The smaller bays are devoted to lighter work; field and mountain artillery, small mortars and siege guns, and projectiles. A large special plant for this latter purpose occupies considerable space in one of the side bays: and this class of work gives employment as a rule to many workmen; to give an idea of its importance, we may say that the company has recently completed an order for the French government for 30,000 finished projectiles.

We publish a section of one of the 66 ton Japanese guns, partly to give an idea of the magnitude of the current work carried on at the Havre factory, and partly because the firing tests of these guns will take place very shortly, and will be attended by circumstances of special interest. The construction of the gun is peculiar, for it has been designed especially for using the new smokeless or semi-smokeless so-called powders, with which very remarkable results are now being obtained, and about which we shall have more to say next week in describing the Hoc polygon of the company. The pressures set up in the gun by such explosives, while comparatively moderate at the breech, are more sustained, so that the chase has to be designed to resist higher strains.

It will be seen from the section that the new 66 ton gun differs in form very largely from the standard type of French naval guns, in which the metal is massed from the breech to beyond the point of attachment to the carriage, and thence to the muzzle is of extremely light porportions. While this form may answer for quick-burning powders, the pressure curve of which drops rapidly from the front of the chamber, it would be quite unsuitable for the newer explosives, that distribute the strains more uniformly along the whole length of the gun. The total length of the 66 ton gun is 41 ft. 11 in., and its bore is 12·6 in.; the outside diameter over the chamber is 51·18 in., and the diameter at the muzzle when the end ring is slightly thickened is 23·31 in. The length of the bore is 38 calibers; the diameter of the powder chamber is 15·75 in., and the distance from the front end of the chamber to the rear of the gun is 94 in. This gun is intended to fire a projectile weighing 990 lb. with a charge equivalent to 616 lb. of brown prismatic powder. As stated above, the reception tests will take place in a few days at the company's polygon, and the carriage is now in place; the projectiles fired will be 990 lb., but the weight of charge will be largely reduced, as a smokeless explosive will be used. The test will be first made to obtain velocities, and from experiments already made with powder of the same class (the so-called B N type) it appears almost certain that velocities will be obtained considerably exceeding that guaranteed—2,300 ft. The tests will then be directed to ascertain pressures; experiences with guns of the same type and bore have shown that they will resist, without any signs of fatigue, strains rising to 42,000 lb. per square inch. Experience has equally shown that under these great pressures no trouble is given by the breech-loading mechanism, the special form of obturator employed being perfectly tight, and at the same time never jamming; the breech can in fact be opened and closed with the utmost facility by one man; recent experiments with a fifteen cent. gun of 36 caliber have given a velocity of more than 2,500 ft., and there is no reason to suppose that an equally high record will not be made with the thirty-two cent. cannon.—*Engineering.*

MODERN GUNPOWDER AS A PROPELLANT.*

By Major F. W. J. BARKER, R.A.

1. Introduction.
2. Distinction between "explosive" and "propellant" as demonstrated by the different action of "old" and "modern" powders on gun and projectile.
3. Ingredients and outline of processes of manufacture.
4. Progressive steps from the old explosive to the new propellant.
5. Powders for the new small-arm magazine rifle.
6. Smokeless powders.
7. Conditions under which gunpowder is now admitted into the service, and precautions to be observed in keeping it.
8. Practical results.

1. IN my lecture to-day, I may possibly have the honor of addressing representatives of three classes of gentlemen who have much to do with explosives and propellants—

1. Those who invent them.
2. Those who manufacture them.
3. Those who use them.

The first two classes are doubtless, and fortunately for us all, in the minority, and I must ask them kindly to accept my apologies, when I address the remarks to be made this evening almost exclusively to those who are the users of gunpowders now in the services.

It is, perhaps, desirable, at the beginning of this lecture, to consider for a moment the meaning of the term "reliable propellant." I submit that it may be popularly and fairly defined for our purposes as a trustworthy speed producer which is properly under control.

2. This being so, I invite your attention to the table before you (table E), showing the gunpowders used in the services, and we shall presently distinguish between the characteristics of the old and well known explosive and modern gunpowders as propellants.

We hear a great deal in the present day about the power of modern guns, the energy they develop, their accuracy, and the armor-piercing capabilities of their projectiles.

Not so much, however, is heard of the propelling agent, or the speed or velocity of the shot, upon which efficiency and power depend, and without which the most powerful projectile ever designed would only be an inert mass of metal.

I, therefore, propose to consider the claims of modern gunpowder to the title of "reliable propellant," and from this point of view to examine its characteristics as a speed producer.

Let us now see what speeds or velocities can be obtained, and by comparing the rate per hour which we are accustomed to consider high, where steam is the

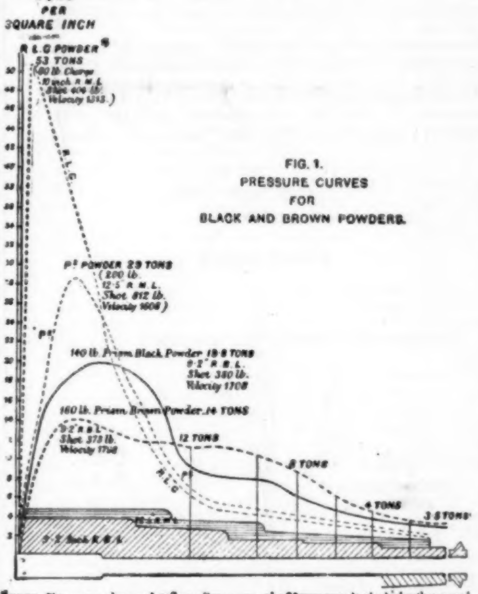


FIG. 1.
PRESSURE CURVES
FOR
BLACK AND BROWN POWDERS.

*NOTE. This is an abnormal or "wave" pressure, the P² pressure is also higher than usual.

propelling agent and a railway train is moving rapidly, with that attained by nearly a ton weight of metal contained in the modern projectile, we may grasp more fully the difficulties to be overcome by modern guns and modern gunpowders.

We are all tolerably well acquainted with the results which have been accomplished by steam, and yet, when we stand on a railway platform and see an express train rush by at a speed approaching sixty miles an hour, it is difficult to avoid a feeling of amazement at the rapidity with which it passes and the propelling power which drives it.

Keeping this example of speed in view, we can better realize the significance of those velocities on the diagram before you, which represent speeds of over 1,365 miles an hour.

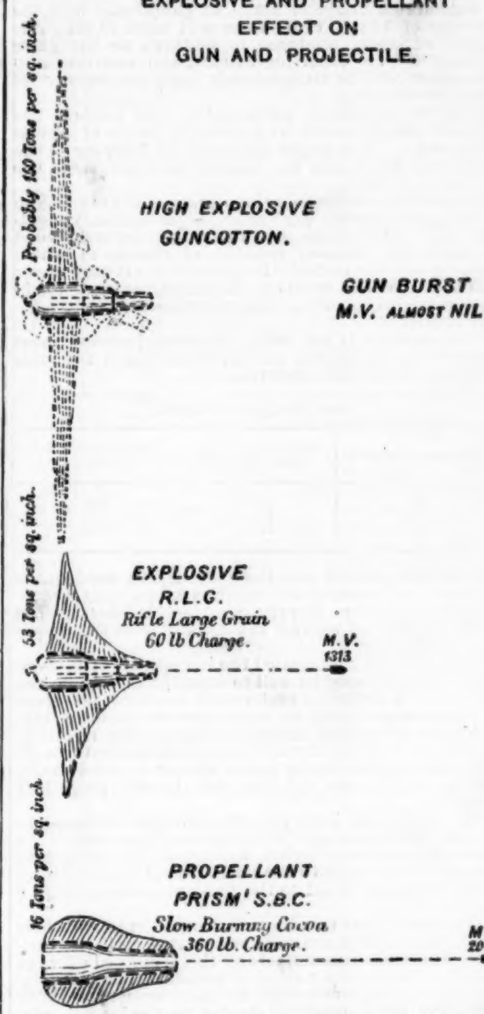
Or, if we compare these results in other words, we find that, before an express train going at full speed from London could reach Portsmouth, a shot, travelling at the ordinary rates of modern projectiles, would pass Gibraltar.

Again, the working pressures of steam range, as a rule, between 30 and 250 lb. on the square inch, according to the nature of the engine employed, while the working pressures of gunpowder are from about 35,000 to 40,000 lb.

The necessity for these comparatively high pressures with gunpowders is due to the fact that the great speed must be obtained in the very short space available in the serviceable length of a gun.

As we are discussing a substance which is generally termed an explosive, it may be well at this point to invite attention to the distinction between "explosive" and "propellant," as demonstrated by the different actions of old and modern powders on the gun and the projectile. The diagram before you (Fig. 2) illustrates in a simple manner what I wish to convey.

FIG. 2.
EXPLOSIVE AND PROPELLANT
EFFECT ON
GUN AND PROJECTILE.



We have here represented in dotted lines three guns, each of which is acted on by a different agent.

First. A "high explosive" guncotton, or nitroglycerin, is used. This destroys the gun, while it hardly imparts any velocity to the projectile.

The enormous pressure developed, probably over 150 tons per square inch, is (as sketched in the pressure curve) too instantaneous for the structure of the gun to resist, or for the development of the velocity of the shot.

With the second gun rifle large grain is used, and this also gives a tremendous strain or sudden shock to the gun, while imparting a low velocity to the projectile.

The third gun is fired with modern brown prism* powder, and you see a very moderate pressure gradually developed, and a high speed given to the projectile.

3. We shall now consider the nature of the substance which makes results such as have been already mentioned possible; and briefly describe the ingredients and processes of manufacture.

Old gunpowder used to be somewhat inaccurately described as a mechanical mixture, the components of which were saltpeter, sulphur, and charcoal—75 saltpeter, 10 sulphur, 15 charcoal.

No mention was made of the water which was always present in greater or less quantities, and hardly anything was known of the real composition of the ingredient called "charcoal."

The new powders, black and brown, are now recognized as a mechanical mixture of four chemical components, the only uncombined element, or simple substance, being sulphur.

The influence of the relation between the proportions of carbon, hydrogen, and oxygen in charcoal is now understood, and has recently been further worked out and developed by Colonel W. H. Noble, royal gunpowder factory; and the action of the fourth ingredient, water, is carefully considered, both in its aspect as at first a retarding and shock-reducing agent, and afterward as an aid in the form of steam (or the two gases H_2O) to the propelling power of the gunpowder.

If we look at the table of ingredients, we see the differences clearly defined.

TABLE A.—*Gunpowders.*

	Old. *Black.*		Modern. *Brown.*	
KNO_3	75 saltpetre		79 saltpetre.	
S	10 sulphur		3 sulphur.	
C	15 charcoal	willow, alder, dogwood	18 charcoal.. straw	carbon. hydrogen. oxygen.
			1·7, 2·2 water	hydrogen. oxygen.

Modern. *Black.*	
75 saltpetre.	
10 sulphur.	
15 charcoal	carbon. hydrogen. oxygen.
1·0, 1·3 water	hydrogen. oxygen.

* A recent lecture before the Royal U. S. Institution.—*From the Journal.*

* S. B. C., slow-burning cocoa.

Let us note the new features here.

Water is no longer looked upon as an unavoidable evil, and the steam or gases produced from it hold a recognized position in the new propellant; while the charcoal has fixed proportions of carbon, oxygen, and hydrogen, which (when properly prepared) it should always contain.

Further, 1 lb. of water will produce 47,030 cubic inches of steam at a temperature of 212°.

Therefore a charge of 100 lb. of gunpowder with the average of 1·5 per cent. water will have 70,545 cubic inches of steam produced, in addition to the gases evolved by the other ingredients, and omitting any allowance for the tremendously high temperature of the ignited charge.

The two vessels of water before you contain the amount which should be present in 100 lb. of service gunpowder. The larger quantity is 2·2 per cent., the maximum limit, and the smaller is 1 per cent., the minimum limit.

It is well to realize that the portion of the old maxim "keep your powder dry" must be considerably modified, and that though modern gunpowder is designed to stand the ordinary changes of climate to which most of our war *materiel* is exposed, yet it may resent artificial roasting, or baking in magazines close to engine room or boilers, as treatment amounting to positive cruelty!

The question is one which, in all seriousness, must be carefully considered, and an inspection of the table before us shows how important it is.

TABLE B.—*Effect of Moisture.*

Percentage of moisture.	Maximum pressure in tons per square inch.	Muzzle velocity in feet per second.
1·5	17·76	1407
1·0	20·19	1523
0·7	22·02	1545

It is thus seen that as the water is decreased so the pressure and velocity are increased, and that the increase in pressure is very considerable when even a small quantity of water is taken away from the proper proportion.

Having briefly discussed the ingredients of modern gunpowder, it may be well to examine in outline the processes, in order to understand some of the steps which have converted an ungovernable explosive into a reliable propellant, capable of producing results as to speed and regularity which compare favorably with any other motive power under similar circumstances, and even with our old and well known propellant steam.

For those who have not time at their disposal to burden their memories with details of manufacture, I have drawn a tree diagram, which indicates enough in a graphic form to show the development of gunpowder from the raw material to the finished product (Figs. 3 and 4).

The roots of the tree show the ingredients and their proportions, while the stem has printed on it the various operations of manufacture, the combined effect of which is to produce a reliable propellant, suitable, by slightly varying the details, for every modern weapon, from the pistol using 18 grains to the largest gun, which requires for each charge 960 lb. of gunpowder.

FIG. 3.
GUNPOWDER TREE.
BLACK.

* *These Charges are undergoing modification, Vide Brown Powder.*

As it is not proposed in this lecture to discuss the manufacture of gunpowder in detail, I shall only name the processes, each of which has a considerable influence on the characteristics of the powder produced.

They are exhibited, as you see, along the stem of the tree, and also on the diagram which is placed beside it.

The branches of the tree are arranged to show the natures of the guns with which the powders are used.

I may here point out that as almost absolute uniformity of character is a necessity for each nature of powder, difficulties in manufacture are experienced, which few, who have not practically studied the subject, can realize.

For example, a day's production represents about a unit or lot of 100 barrels—10,000 lb.

This large quantity must be as nearly as possible absolutely uniform in itself. That is to say, every charge from it, which is fired from the same gun under similar circumstances, should give identical results as to speed and pressure.

This batch of powder is, however, made in many machines, on the out-turn of which the weather and temperature exert considerable influence; and, besides this, the machines are tended and worked by different men,

TABLE C.—*Progressive Steps towards obtaining Gunpowders suitable for Modern Rifled Guns.*

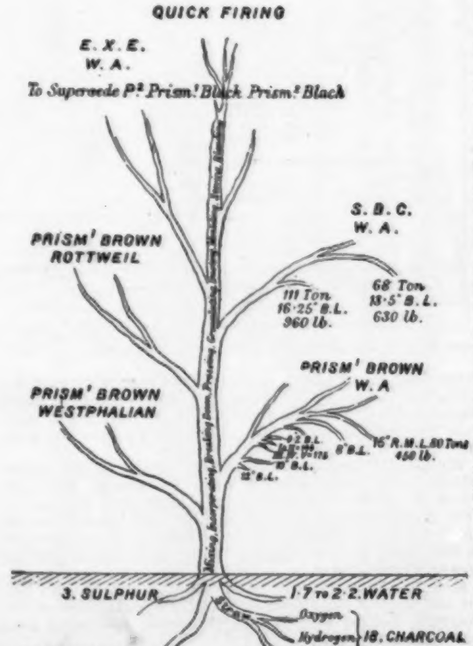
System or method adopted.	Powder.	Result.
Change of size (Increase in).	R.L.G., introduced 1866 P. " 1871 P.² " 1876 R.L.G.⁴ " 1887	Diminution in rate of burning. Reduction of shock or blow given by the powder on ignition.
Change of density (Increase in).	Pebble. Prism¹, black. Ditto, brown. Ditto, S.B.C.	Reduction of rate of burning. Reduction of initial strain in the bore of the gun.
Change of form and moulding.	Disc Pellet. Sphere. Cylinder. Hollow cylinder. Cube. Perforated prism.	Regularity of ballistics in units of powders manufactured under the same conditions. Final break-up along the lines of least resistance, giving additional surface of combustion and production of gas as the projectile travels along the bore.
Change of texture, granulating, and moulding.	Masses or conglomerate lumps formed of compressed grain. Progressive or Fossano Prism¹, black, 1881; ditto, brown, 1884; S.B.C., 1887; and E.X.E., 1887.	Regularity of density. " pressures. " velocities.
Change of composition.	Prism¹, brown. Ditto, S.B.C. Ditto, E.X.E. Water recognized as an ingredient.	Additional control over rate of burning, pressures, and velocities.
Blending.	P. and S.P. Prism¹, black. " brown. S.B.C. E.X.E.	Control over ballistics of lots or large batches. Regularity of results in batches, lots, or charges of powder.

each of whom has what may be termed a personal error, which is enough in each process to make a considerable difference in the portions of the batch or lot made by those working at the same time.

The consequence of this would be that, if unadjusted, the lot of 10,000 lb. as a whole would prove to be most irregular in its characteristics and unreliable in its shooting.

To overcome this, a constant systematic method of intermixing the various batches from each process is adopted; and this (which is termed blending), being carried out on scientific principles, gives a uniformity to each unit of 10,000 lb., which could not otherwise be obtained; and we are thus provided with reliable and

FIG. 4.
GUNPOWDER TREE.
BROWN.



uniform batches or lots of the propellant under discussion.

4. We are now in a position to consider how the new propellant has been developed from the old explosive, and the various steps which during the last few years have completely altered the character of gunpowder.

The story of the unsuitability of the early black powders to arms of precision is now an old one, and many of us remember the various methods proposed to obtain regularity, and to reduce the violence of gunpowder, when the requirements of modern guns were beginning to be understood and acknowledged.

The large charges of even the most suitable black powders, in the very heavy M. L. guns, were found to strain the inner steel tubes, and had a tendency to split them, and further efforts were necessary to control the violence of gunpowder. The diagram of progressive steps, to which I now invite your attention, will help us to form an idea of the manner in which gunpowder has been gradually developed from an uncontrollable and uncertain explosive into a reliable propellant and servant.

There are only two of the methods in the diagram which our limited time will allow us to mention in detail.

The first is density, which in the modern powders has been largely increased, and is now most carefully attended to.

The workmen with the various machines take specific gravities of each batch, and these results are again checked in the laboratory.

This density, which varies in the out-turn of the same machine with every change of temperature, is a continual source of anxiety to all powder makers, and the difficulty of manufacturing within the proper limits, which are very closely defined, is considerable. This was amusingly brought before me by a leading member of one of the large private gunpowder factories, who came to consult us at Waltham Abbey about the powder he was making.

He said he was positively afraid to sit on one of his barrels of powder, on its way to proof, for fear of spoiling its density!

The actual results obtained by firing powder of different densities are shown in this table:

TABLE D.

Density.	Velocity. Feet per second.	Pressure. Tons.
1·790	2066	17·5
1·80	1944	14·6
1·82	1894	12·7

Thus we find that as the density is increased, the velocity and pressure are decreased, and that control over density gives considerable control over the velocity, and also over the pressure or strain on the gun.

The second detail of the diagram to be brought to notice is the change of form and moulding.

It needs no explanation to demonstrate that a charge consisting of regularly shaped moulded powder of uniform size will give (other things being equal) more uniform results than could be obtained by an equal weight of irregular grains or lumps.

But the modern shape, the perforated moulded prism, possesses further advantages over the other forms which are worthy of consideration.

If we take any of the old grain powders, or a mass of lump like P², we know that it burns from surface to center.

This being so, the surface of combustion decreases, as the shot travels in the bore, or as the space behind the shot increases. That is to say, we find a reducing evolution of gas when you really most require an increasing one; and hence the speed of velocity of the projectile is not developed in the most satisfactory manner.

On the other hand, if we now look at the perforated prism, we find that, as the outside surface is diminished by combustion, so the inside surface of the perforation is increased; thus we see a tendency to keep up a constant supply of speed-producing gases; and, further, when the combustion reaches a certain point, it is more than probable that the prisms break up across the lines of least resistance, *aa*, *bb*, etc., thereby presenting

twelve new surfaces, f, f^1, f^2, etc., for combustion; fully developing the progressive character of the powder, and helping the projectile along as its speed is accelerated and the resistances which it has overcome from friction and air are increased.

I here submit for your inspection actual portions of prisms which have been only partially consumed, when fired from a gun, and you will observe that the break up across the lines of least resistance is very clearly demonstrated.

We must now note that as the development of guns and gunpowders proceeded, so also efforts were made to design powders distinct in character and specially suited to the many weapons with which they are now employed, in charges (as I have already stated) varying from 18 grains to 960 lb.

We have in our English services, as you all know, a huge number of guns and small arms of different natures, each class of which requires a powder of a particular kind to develop its powers, or to suit its strength; and experience now proves that special powders must be made in order to fit or suit the various classes of highly finished and accurate weapons now in use, not only for the safety of the weapons themselves, but also to enable them to give the most satisfactory results in shooting.

For example, a heavy gun must have a comparatively slow-burning powder, as a quick small arm gunpowder would probably blow it to pieces. Again, a small arm rifle, if fired with slow-burning powder, would give its projectile such a low velocity as to be practically useless.

This "fitting" of powders to guns and small arms is the manufacturer's difficulty, and has led to the comparatively long list which we have already referred to, containing fifteen different gunpowders.

5. I may here instance one of the most recent examples of fitting powder to a weapon; namely, the perforated pellet for the new magazine rifle.

The first attempts were made with all kinds of powder, from the cheapest which could be obtained from the trade to the most expensive sporting and rifle powders, besides those manufactured at the government factory. The early experiences were most unsatisfactory; irregular velocities and very high pres-

sures being the rule; and the cheap powders demonstrated their qualities at once by the wildest shooting.

The required propellant to be used with the magazine rifle (a cylindrical pellet made from a fine-grain powder) was only satisfactorily obtained, after more than 120 distinct experiments were carried out (each involving several days' work), the velocities and pressures of all the rounds for each experiment being carefully observed and recorded.

This pellet, here shown, is now being manufactured at Waltham Abbey, and has given the best target at 1,000 yards ever obtained by a black powder.

6. I now propose to bring before you the smokeless powders; but, as there are, up to the present date, none introduced into the services, I can only mention those which in the near future may be adopted.

For reasons which we can all understand, I am *not* of course permitted to indicate any particular powder as that which may probably be accepted; but, as there are types of nearly every possible combination, specified in the various patents recently taken out, we can discuss some of them now with clear consciences, and without an infringing inventor's "fear of punishment or hope of reward."

I shall only very briefly allude to the character and chemical composition of these powders, as they were so fully discussed in the very able and interesting lecture given by Mr. Deering in this Institution last year,* and I shall therefore confine my remarks chiefly to their qualities as propellants.

These so-called smokeless powders may be classified for practical purposes under three heads, viz.:

Modifications of

1st. *Guncotton.*—Trinitro-cellulose, $C_6H_7O_2 3(NO_3)$, obtained by the action of nitric acid upon cotton, viz.—

$$\underbrace{C_6H_7O_2 3(HO)}_{\text{Cotton or cellulose.}} + \underbrace{3(HNO_3)}_{\text{Nitric acid.}} = \underbrace{C_6H_7O_2 3(NO_3)}_{\text{Guncotton.}} + \underbrace{3H_2O}_{\text{Water.}}$$

2nd. *Nitro-glycerin.*—$C_3H_5 3(NO_3)$ obtained by the action of nitric acid on glycerin.

3rd. *Picric Acid.*—Trinitrophenole, $C_6H_2 3(NO_2)O$, formed by boiling "carbolic acid" or phenole with fuming nitric acid.

These chemical compounds are too sensitive for use by themselves as propellants, and are, with the exception perhaps of pure picric acid, very easily detonated.

We know that some substances have only one way of burning, as, for example, paper, wood, etc., which, when ignited, are quietly consumed.

Others, again, have two, as the ordinary gunpowders, which burn or deflagrate in air, and when confined burn with greater rapidity, causing noise or explosion.

The bases of the smokeless powders are liable to a third and more powerful action upon ignition.

This is an irresistible and instantaneous change of condition, almost without flash or smoke, and with a sharp report quite unlike the explosion of gunpowder.

This violent action, which is utterly destructive to the strongest metal, and would blow any gun to pieces, is called detonation.

To avoid this, the substances which have been mentioned (gun cotton, nitro-glycerin, and picric acid, etc.) are slowed, or retarded, in combustion, either by chemical combinations or mechanical mixtures with inert substances, such as gum, resin, camphor, etc., and by these means, and by very nice adjustment, the risk of detonation is averted, while the propelling power is to a great degree retained.

I may here, perhaps, mention a recent practical experience, which clearly demonstrated the difference between explosion and detonation, as usually understood, and also how these high explosives differ under different circumstances.

Some smokeless powder, made from one of the substances on the list before you, was being tested at proof.

Satisfactory results had been obtained while using one of the retarding agents; and a small charge of thirty grains gave a velocity of 2,000 feet with moderate pressure.

Three grains were added to the charge, and the thirty-three grains fired. This small quantity detonated, shattered the powerful and heavy steel breech block of the experimental proof rifle, giving a pressure probably over fifty tons on the square inch.

The aim, therefore, in the new smokeless powders, where high explosives are used, is, by chemical and mechanical means, to render detonation impossible, and also to use a retarding or slowing agent, which will neither produce residue nor smoke, and will give high and regular velocities with moderate and regular pressures; and, in fact, convert a violent explosive into a reliable propellant.

I need hardly say that this has been, and still is, a tremendous difficulty; but, like many other difficulties, it seems now in a fair way of being overcome, by the scientific knowledge and untiring energy of those who have taken it in hand, and some of the results recently obtained demonstrate the great strides made toward obtaining the objects just mentioned.

Five rounds gave recently in the magazine rifle:

M. V. in feet.

2,133
2,121
2,135
2,106
2,110

With an average pressure of 16 tons on the square inch.

Compare this with the muzzle velocity of the Martini-Henry, 1,310 feet per second, and then we see the advance made!

If these results with smokeless powders can be regularly obtained, if the powder will keep, and always give good shooting, without too rapid wear of the barrel, if it be free from all risk of detonation under service conditions, there seems little remaining to be desired (except, perhaps, that possible enemies should *not* possess it), and the sooner it is adopted the better. But when it is remembered that our ordinary peace expenditure of small-arm ammunition amounts to many millions of rounds annually, and that deterioration under changes of climate, or a serious accident at

* Journal R. U. S. Institution, vol. xxxiii., No. 148, p. 603 *et seq.*

TABLE E.—*Showing the Conditions of Acceptance of Service Powders.*

Nature.	Small-arm or gun in which fired.	Charge of powder.	Weight of projectile.	Density.		Moisture.		Muzzle velocity.		Pressures.		Remarks.
				Min.	Max.	Min.	Max.	Min.	Max.	Max.	Mean.	
						per cent.	per cent.	f.s.	f.s.	Tons per sq. in.	Tons per sq. in.	
R.F.G.	Snider rifle	70 gr.	480 gr.	1·58	1·62	0·9	1·2	1250	1290	—	—	"Rifle pistol," having the same density and moisture as R.F.G., should give a muzzle velocity of 680 f.s. when fired in 18-grain charges from an Enfield pistol.
R.F.G.²	M.H. rifle	85 gr.	480 gr.	1·72	1·75	0·9	1·0	1310	—	—	—	
						1·0	1·1	1300	—	—	—	
						1·1	1·2	1290	—	—	—	
M.G.¹	1-in. Nordenfelt	625 gr.	3,170 gr.	1·75	—	1·0	1·3	1420	—	12	—	
*Q.F.²	6-pr. Hotchkiss Q.F. gun.	1 lb. 15 oz.	6 lb.	1·75	—	1·0	1·3	1800	1840	14·5	14·0	
R.L.G.	9-pr. M.L. gun	1¼ lb.	9 lb.	1·67	—	—	—	1385	1435	—	—	
R.L.G.²	13-pr. M.L. gun	3 1/16 lb.	13 lb.	1·65	—	1·0	1·3	1540	1590	16·5	16·0	
R.L.G.⁴	64-pr. M.L. gun	11 lb.	67½ lb.	1·65	—	1·0	1·3	1380	1420	17·0	16·5	
P.............	6-in. B.L.	34 lb.	80 lb.	1·75	—	1·0	1·3	1890	1930	16·5	16·0	
S.P...........	12-pr. B.L.	4 lb.	12½ lb.	do.	—	do.	do.	1700	1740	15·0	—	
P.²	12·5-in. M.L.	200 lb.	812 lb.	1·75	—	1·0	1·3	1540	—	22·0	21·0	
Prism¹—black .	8-in. B.L.	100 lb.	210 lb.	1·76	—	1·0	1·3	†2000	†2050	18·0	17·5	† These velocities are over 1,300 miles an hour.
Prism¹—brown	6-in. B.L.	55 lb.	100 lb.	1·80	—	1·7	2·2	1960	†2000	16·5	16·0	
	11-in. B.L.	295 lb.	655 lb.	do.	—	do.	do.	1980	†2020	18·5	18·0	
Prism E.X.E...	6-in. B.L.	48 lb.	100 lb.	1·80	—	1·5	2·0	1960	†2000	17·5	17·0	
Prism S.B.C. ..	11-in. B.L.	360 lb.	655 lb.	1·85	—	1·7	2·2	†2010	†2050	16·5	16·0	
S.A. Pellet	Magazine rifle.	71½±2½ gr.	215 gr.	..	..	0·9	1·3	1850. ±50		20·0	19·0	

* The size of Q.F.² powder is ½-inch square by 3/16-inch thick; about 270 pieces to 1 lb. It is manufactured by the trade.

the rate of one per million, would inevitably condemn the new powder (that is to say, twenty or thirty men seriously injured by unexpected detonation), it must be admitted that those who are responsible for the introduction of these powders are bound to test them to the fullest degree before placing them in the hands of our soldiers.

7. We now come to the consideration which is of such importance to all of us who are, or may be, users of these most powerful propellants—namely, under what conditions are they admitted into the service, and what qualifications must they exhibit before they pass from the hands of the manufacturers to those who may be called upon to use them under circumstances of the gravest danger to their country or to themselves?

If we examine table E, which enumerates the conditions to be fulfilled before powders are now admitted into the service, we observe speeds to be given to the projectile, laid down as essential, which exceed 1,300 miles an hour. They must be uniform, that is to say, the independent shots fired at proof from each batch of powder, before acceptance, must not vary from the mean of all the shots as much as 6⅔ miles an hour, and the maximum variation, between the highest and lowest limit, is confined to 40 feet per second, not very much faster than the quick running speed of a man.

It should be remembered that this regularity is to be maintained, notwithstanding three other variables which may exist, viz., the manufacturing limits of the weight of the projectile, its grip, and the size of the bore of the gun.

The pressure or strain on the gun is strictly limited, and the water, or moisture to be contained, is clearly specified. The quantity of water, upon which the keeping qualities of the powder chiefly depend, is so regulated that the limits (as we have already noted) are those within which it will remain under ordinary conditions; that is to say, 100 lb. of modern gunpowder with its 1·7 to 2·2 per cent. water will retain this amount under ordinary conditions of climate, and, therefore, its speed-producing powers, and the pressures to be expected, are not easily affected.

I may here note that recent practical experience proves this. Prism powder, E.X.E., sent to India for two years, gave, on its return home, almost the same results as those which were recorded when a portion of it was fired before leaving England.

On the other hand, it is well again to be reminded that if unduly dried, and artificially heated or wetted, it is as liable to give irregular results as the engine whose boilers are subjected, at one time, to forced draught and undue production of steam, and, at another, to the failing supply which smouldering fires and neglected stoking will produce.

It is therefore most necessary to attend to the condition of our modern propellant, and after its issue to the services, the water question is the chief one.

The powder should be kept from undue influence of moisture, and should not be exposed to conditions which may tend to drive the proper quantity of water out of it.

Frequent examination, as laid down in the regulations, is necessary, and facilities, which should be utilized, are now afforded at home and abroad for testing the moisture, and informing us as to the condition of our propellant.

8. We are now in a position to consider the practical results which have recently been achieved, and by again comparing the powers and characteristics of the old explosive with the modern propellant, we shall more fully emphasize the claim which is submitted for modern gunpowders in this lecture. The diagram of pressure curves presented in Fig. 1 indicates pretty clearly the difference in the character of the old black and modern powders.

Two guns, a heavy muzzle loader and modern breech loader, are shown in section. Both are perforated at certain points along the bore, and pressure gauges are inserted.

A vertical scale of half inches is adopted, and the number of tons pressure recorded by the various gauges at the different points is measured vertically for each nature of powder and gun.

By joining the points (marked 12 tons, 8 tons, etc.) which represent the pressures, curves are obtained which show, in a pictorial form, the actual pressure curves or strains to which the guns are subjected.

Thus, in the first instance, the suddenly rising and rapidly falling dotted line represents the enormous pressure of 53 tons per square inch, sometimes produced by old black powder—Rifle Large Grain—while the shot only attained to a velocity of 1,313 feet.

The other intermediate curves tell a similar story, but at the same time indicate great progress.

Now, look at the heavy dotted line, the pressure curve for brown powder, and you see the curve of a true propellant. Here we see a pressure of 14 tons gradually produced, and slowly diminishing toward the muzzle of the gun. In fact, we see the pressure developed by the propellant adapting itself to the strength and form of the gun in which it is used.

To demonstrate the regularity of modern gunpowders, I here select two, designed by Colonel W. H. Noble, Superintendent R.G.P.F., as being typical of the reliable propellant class; and I submit that the results shown on the table before us speak for themselves.

They were obtained at ordinary and recent proof of Waltham Abbey gunpowder carried out independently at Woolwich.

TABLE F.

Nature and charge.	M.V. in feet per second.	Rate per hour in miles.	Mean error in miles per hour.	Chamber pressure in tons per square inch.	
S.B.C. / W.A. 360 lb.	2004	1366	0·47	14·9	
	2003	1365	0·23	14·8	
	2003	1365	0·23	14·9	
E.X.E. / W.A. 48 lb.	1961	1337*	0	14·1	*Fractions omitted.
	1964	1339	2	13·8	
	1960	1336	1	14·0	

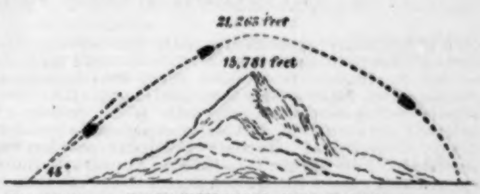
There is another result which, although hardly within the scope of this lecture, ought not to pass without notice, as it shows in an interesting manner what modern guns with modern gunpowders are capable of doing.

If we could imagine the highest mountain in Europe, Mont Blanc, placed between us and Woolwich, a shot, which was fired in July, last year, would have passed 5,482 feet above its summit, and lodged on the other side in Woolwich. (Fig. 5.)

To recapitulate:

We have seen that the old black powders were unrestricted as to pressures. The strains to which they

FIG. 5.



Shot 380 lb. RANGE 21,800 YARDS. OVER 12 MILES.
M. Velocity 2375 ft. OBTAINED IN 1888.

subjected the guns were not at first known; and when they were discovered, they were found to be very high and irregular.

The modern powders give low and regular pressures.

Again, if the velocites produced by the old powders reached a certain height, they were considered satisfactory, and the powders passed into service.

Now, a high and low limit of speed are closely defined, and the low limit is in most cases nearly half as much again as that obtained not many years ago.

Further, the uniformity of results cannot fail to strike any careful observer.

Take as examples those already quoted or the modernized type of pebble, viz., "Selected Pebble," which at recent proof gave in consecutive rounds:

TABLE G.—*Waltham Abbey Selected Pebble.*

Gun.	Muzzle velocity.	Mean variation.	Chamber pressure in tons.	
	feet per second.			
80-pr. B.L.	1926	1	15·1	3 consecutive rounds fired in 6-inch B.L. 80-pr.
	1925	1	15·25	
	1921	3	15·0	
12-pr. B.L.	1711	1	12·9	5 consecutive rounds fired in 12-pr. B.L.
	1711	1	12·6	
	1717	5	12·6	
	1716	6	13·3	
	1714	2	12·5	

When we consider such results as these, together with those previously noted, I submit that the claim

of modern gunpowder to be a "reliable propellant" (or "trustworthy speed producer, properly under control") must be admitted as fairly established.

At the same time it must be *constantly* borne in mind that these results can only be maintained by unremitting care and attention to the condition of our guns, our projectiles, and our gunpowder.

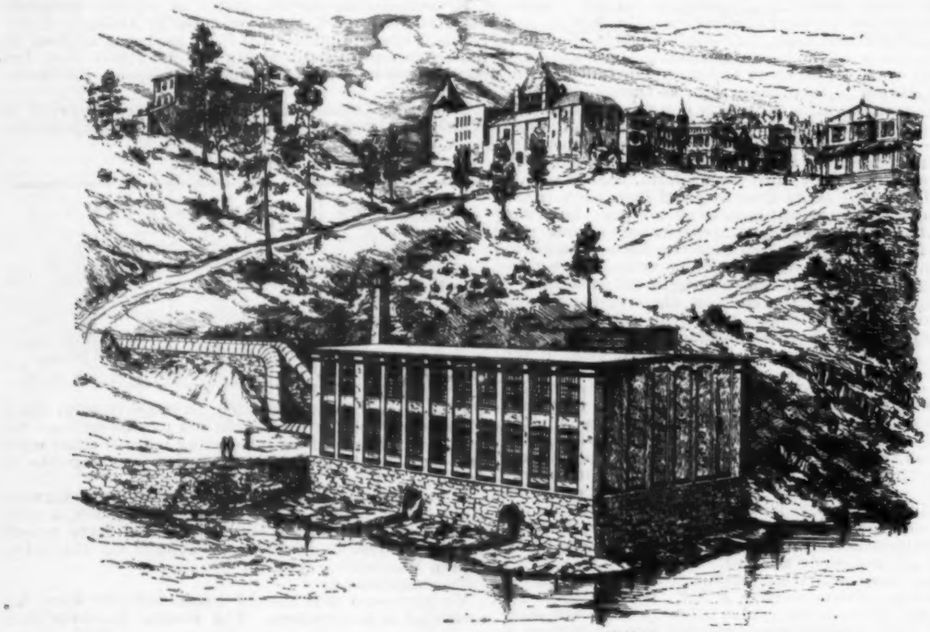
In conclusion, I would point out that where great results are obtained, great efforts and care have been bestowed. Each gun fired and every pound of gunpowder expended (even when one charge alone contains 1,000 lb.) represents a large amount of thought, calculation, and labor.

The efficiency of the best of our guns is dependent upon the quality and condition of the powder employed as the propelling agent and the proper and intelligent use of the ammunition supplied.

I therefore submit that a sound knowledge of the general principles which govern the manufacture of gunpowder is most useful; and that a *special* knowledge of the best means suitable for its care and preservation as a propellant is indispensable for those whose duties may call them to any quarter of the globe, and who belong to services whose responsibilities are so closely connected with the honor and safety of our British empire.

In the course of the discussion which followed the lecture the following tribute was paid to Gen. Rodman by Major-General Wardell:

I should wish to say only a few words, since it is not for me to make any reply to what has been said concerning the able lecture we have listened to. I was, however, glad to hear Gen. Rodman's name mentioned in the discussion, because I think the debt we owe to him has never been adequately acknowledged. I look upon General Rodman's experiments, which are detailed in his book, "Properties of Metal for Cannon, and Qualities of Cannon Powder" (Boston, 1861), as the basis of our prismatic powder. He called his powder *perforated cake cartridge*. It was made in disks the size of the bore of the gun. The disks varied in thickness for the gun required, and they were perforated with longitudinal holes parallel to the axis of the piece. He carried on a great many experiments with this powder, and finding that these disks were certain to break up more or less in transit, he divided them into hexagonal prisms which fitted closely together, in order that there should be due control over the form of the powder. I believe I am correct in stating that prismatic powder, first of all known as "Russian" prismatic powder, was introduced into Europe by a Russian military commission, which visited the United States about the time of the civil war, adopting General Rodman's idea. In his work already referred to he demonstrated the mathematical theory of the powder, which has been so ably touched upon by Major Barker in his paper, and of course he also proved his case experimentally.



SPOKANE FALLS ELECTRIC LIGHT STATION.

ELECTRICAL WORKS AT SPOKANE FALLS.

An Eastern visitor traveling through the West cannot fail to be impressed with the remarkable developments which are everywhere noticeable in the progress of electrical work in the young and enterprising cities, says a correspondent of the *Western Electrician*. There is hardly a town to-day of 2,000 people on the entire line of the Northern Pacific Railroad which has not its electrical plant or street railroad system, and some of these plants would do credit to an Eastern town many times the size.

Perhaps the best illustration of this development is to be found in the young city of Spokane Falls, now a bustling town of 35,000 people, the supply center of Eastern Washington, Eastern Oregon and Idaho. This city is located on the banks of the Spokane River, which is the discharge stream of the Cœur d'Alene lake in Idaho. The river makes a series of cascades and falls within the city limits of some 124 feet in height, gathering itself together for one final plunge of 70 feet, and the power developed is used for operating the industries of the city, the electric light and street railroad plants, and, in fact, everything requiring motive power. According to Col. J. T. Fanning, the hydraulic engineer, of the Washington Water Power Company, of Spokane Falls, the power of the water at the lowest stage is equivalent to 30,000 horse power. In the spring of the year the flow of water often reaches 25,000 cubic feet per second, and by a system of head-gates at the mouth of the lake the flow could be so regulated as to give a steady power all the year round of 50,000 horse power.

The Edison Electric Illuminating Company occupies the lighting field in the city, and its plant is the most extensive individual plant west of Denver, while the rates charged would make the average Eastern customer of lighting companies green with envy. The Edison Company started about three years ago, purchasing a small plant of 300 incandescent lights and 15 arcs. In the great fire which visited Spokane Falls on August 4, the station was fortunately saved from the conflagration, but the pole lines in the business part of the city were destroyed. These pole lines have since been duplicated in splendid form; and the writer saw in Spokane Falls some of the best outside construction that it has ever been his good fortune to inspect.

The overhead work on Front Street, Main Street, and Riverside Avenue, on each of which the pole line is fully a mile in length, is of a model character. All the poles are 50 feet in height, with 10 inch tops, as straight as arrows, well painted, bound with hoop iron, and are stepped. At the time of the fire the plant of the company furnished 1,200 incandescent lights and 135 arcs, all run by water power in a single station. Immediately after the fire the demand for light was augmented greatly, two temporary stations were constructed, and the capacity of the plant was increased to 5,000 incandescent and 350 arcs.

The company uses the Thomson-Houston arc system and the Edison incandescent. Four Victor turbine wheels are operated in the temporary stations. Every printing house in the town is run by the current, and motors are used in most of the small manufactories and for the bulk of the elevator work. The forty motors now in use take about 125 horse power. The company uses the Sprague, Thomson-Houston, C. & C. and the Eddy motors, all of which give good results. The company is now building what is destined to be perhaps the best water power station in the United States.

Some eighteen months ago the Washington Water Power Company obtained possession of what is known as the main fall of the river. This power has a head of 70 feet, and is a confluence of various channels of the upper river. According to the engineer's estimate 15,000 horse power may be utilized. This site was selected by the engineers of the Edison Company as the one place where absolutely reliable power could be had, where water could always be obtained without danger of interruption from the breaking of dams or the washing out of bridges, and where the station could be enlarged to suit the capacity of a town of 100,000 people. The plans of the station were prepared by Henry A. Herrick, C.E., the hydraulic engineer of the Washington Water Power Company, under the superintendence of Col. J. T. Fanning of St. Paul, consulting engineer.

The building is 65 by 120 feet, two and a half stories high. It is of fire-proof construction. The dynamo floor is of girder iron with galvanized iron arches, filled in with concrete and artificial stone. The electrical battery occupies one end of the building, the arc switch-board the other. The steam heating arrangements, work-shops, elevator, etc., are in an annex to the building. The wheel room and foundations are built in granite obtained in neighboring quarries, and 2,500 perch of granite alone, with 1,000 barrels of cement, were used on the foundations. The contract for the iron work including the iron floors, girders, water wheels, and flumes, was let to the Stillwell & Bierce Manufacturing Company, of Dayton, Ohio. The gross weight of the order of this one concern alone amounts to 600,000 lb.

The water is conducted to the station in two immense parallel 5-16 inch steel pipes, 7 feet each in diameter, and is taken from granite gates at the dam, and carried 400 feet to the building. The two flumes are carried through the building parallel, and six sets of wheels are fitted up on each flume. The wheels used are of twin horizontal pattern, 10-inch wheels being used in the incandescent plant, and 15 inch wheels in the arc plant. The 12 sets of wheels will give 2,700 horse power. The 8 sets now being equipped will give 1,500 horse power. The penstocks are equipped with gates on each wheel shaft, so that any one of the twelve wheels can be shut down without impairing the operation of the others. The contract calls for the delivery of eight of these wheels to begin with, and the foundations will be made for the full complement. In the incandescent department each pair of 10 inch wheels will drive a pair of No. 20 Edison dynamos or their equivalent of alternating machines. These wheels will make 1,000 revolutions per minute. In the arc department the wheels have a capacity of 375 horse power each, and will drive six arc dynamos of 50 lights each. The shaft on these wheels will be equipped with friction clutch pulleys, so that any one machine can be shut off or thrown on. They will make 675 revolutions per minute. Arrangements are made in the station for supplying street railroads with current. The electrical equipment of the station, when the first wheel is turned over, will be 8,000 incandescents and 500 arcs. The ultimate capacity of the plant is figured at 12,000 incandescents and 1,200 arcs. The building is located within 500 feet of the heaviest lighted center, and the city spreads out in all directions from the station.

At present the company is lighting the majority of the residence and business houses of the town. The city is lighted under contract with the company with 100 Thomson-Houston arc lights. The largest consumer of the company is the Hotel Spokane, situated about 1,500 feet from the station, where about 800 16-candle power lamps are used.

[Medical Age.]

THE ACTION OF CAFFEINE ON THE MOTOR AND RESPIRATORY FUNCTIONS IN THE NORMAL STATE AND IN INANITION.

By MM. Germain Sée and Lapicque.

Translated by Dr. E. P. Hurd.

History.—Travelers have long given astonishing accounts of the stimulating properties of certain vegetable productions of which primitive populations make use as helps to the accomplishment of painful tasks when suitable supplies of nourishment cannot be obtained. In all parts of the world, we find some one of those marvelous plants which enable the negro or the Indian to make long marches without provisions, through immense, cheerless deserts; in South America the coca, the mate, the guarana; in Africa, the kola nut; in Asia, tea and coffee. Europeans have naturally sought to verify and utilize the precious qualities of these natural products, and tea and coffee have come into common use among all civilized nations, being sought for especially as stimulants of the intellect; and many recent experiments show what service they can render in facilitating muscular work.

Now it is a notable fact, as the labors of chemists have shown, that almost all these substances, with the exception of coca and a few others, contain the same alkaloid, viz., caffeine. It is, then, to the study of the physiological properties of this alkaloid that we must look for the explanation of those singular phenomena which attend the use of these substances.

Many physiologists have already attacked the question, and the facts that have accumulated are numerous. But hitherto not much light has been shed on the intimate mechanism of the motor properties of caffeine; on all sides we find contradictions. According to some, the specific action of the poison is manifested on the muscles; according to others, on the nervous system exclusively. All the products characterized by the presence of caffeine have been denominated waste-restraining aliments (*aliments d'epargne*). This notion has remained vague, and researches have not clearly indicated the slowing of the nutritive processes which it was expected to find. It seemed to us, then, that at a time when endeavors were being made to utilize in the army the properties of caffeine, it was important to undertake again the study of this substance, and to define with some precision its mode of action on the functions of motricity.

First of all, before explaining the facts, we must be sure of their reality. Now this does not seem to be a matter of doubt. Besides the accounts of travelers (which are too concordant to warrant the supposition they are inaccurate), we have recent experiments which are sufficiently demonstrative. We will cite only the following fact:

One of us has been able on several occasions to go forty hours without food, and during this fast to perform a whole day's march without fatigue, simply by consuming a few little cakes of kola nuts. These cakes are such as Professor Heckel, of Marseilles, has successfully experimented with in the army.

From all the experiments thus made, *grosso modo*, on man, it results very clearly that caffeine, and the vegetable compounds containing it, possess the two following properties:

1. To greatly facilitate muscular work and enable one to continue at work a long time without fatigue.
2. To enable one to go without food for a variable length of time, even if he has considerable work to perform.

We will now see how physiology explains this action, and will divide our task into two parts, because, in fact, the question presents itself in two distinct forms.

a. How does caffeine facilitate muscular work?
b. How does it enable one to work without effort during fasting?

We need not speak here of the other medicinal properties of caffeine except as far as these actions directly concern its influence on the motor functions in general.

HOW CAFFEINE FACILITATES MUSCULAR WORK.

We will first of all state our conclusions, and then justify them by our experiments and by criticism of the labors of our predecessors.

(1) *Caffeine augments the activity of the motor part of the nervous system, medullary and cerebral.*

(2) *Caffeine prevents the breathlessness and palpitations consecutive to violent work.*

1. "*Caffeine augments the activity of the nervous system.*" This excitation of the functions of motricity has been noticed ever since the action of caffeine has been studied. The first observers, in their experiments on man, were in accord in their conclusions respecting a nervous excitation. Then came the graphic method; physiologists attempted to enter more deeply into the analysis of the phenomena by means of myography, and thenceforth uncertainties and contradictions began. It is because, in fact, the frogs employed

in the experiments of myography present reactions irreconcilable with each other, in appearance at least. Vulpian pointed out this fact as early as 1864. Schmiedeberg showed that the red frog (*Rana temporaria*) and the green frog (*Rana esculenta*) behave quite differently under caffeine poisoning. The green frogs present in the clearest manner an excitation of the spinal marrow, manifesting itself by convulsions similar to those caused by strychnine; hence the experimenters who employed green frogs rightly concluded that the action of caffeine was spent on the nerve centers. The red frogs were taken with contractures progressively supervening without convulsions; the muscles became completely inexcitable, whether directly or by the intermediation of the nerves, therefore the experimenters who employed red frogs concluded with no less certainty that caffeine was a muscular poison.

The explanation of Schmiedeberg has not been admitted by the physiologists who have come after him. Leblond, in some experiments made in common with Mendelsohn, disputes the specific difference in the action of caffeine in red frogs and in green frogs. Without denying the action on the medullary nerve centers, quite evident in the case of convulsions, he puts the action on the muscles foremost. He remarks, in fact, that even in frogs that have convulsions, the curve of the muscular contraction changes, which demonstrates, he thinks, a peripheral action.

We have repeated these myographic experiments, and these are the results obtained.

The difference noted by Schmiedeberg between green frogs and red frogs is constant, and is remarked by all observers. In a long series of comparative experiments, we have never found an exception. In the experiments of M. Leblond, if examined with care, we note this difference very well, though it is not, however, special to caffeine, but obtains as well with brucine and veratriin.

Having, then, verified the fact that caffeine produces in red frogs muscular contractures (which are certainly of peripheral origin, as the section of the nerves and the destruction of the spinal cord in no way alters the result), and in green frogs a violent excitation of the spinal marrow, we inquired which of these two reactions would be likely to be presented by man. *A priori*, it seemed probable that it would be the nervous mode, in fact, these muscular contractures of the red frog can only produce total immobility by a cadaveric rigidity which does not at all explain the facility of movements (so commonly noted) in mammals. In the latter, moreover, it is easy to produce convulsions by caffeine; even among the lower vertebrates, the case of the red frog is an isolated one. The toad and the tortoise, as we know by several experiments, clearly manifest a hyperexcitability of the cord when they have taken caffeine.

There remains now to consider the modification of the form of the muscular contraction, a modification characterized by a lengthening of the period of de-contraction. We have very plainly observed it in the green frogs, and we have also seen it in the toad. This modification, by the way, is not due primarily to a muscular excitation, but is entirely of central origin, as we can prove by the following experiments:

If we separate the sciatic nerve from the cord, at the moment when its excitation determines in the corresponding gastrocnemius the curve characteristic of caffeine poisoning, the curve immediately returns to the normal type. If, on the other hand, we ligature *en masse* one of the posterior members, the sciatic nerve being excepted, so as to preserve the gastrocnemius of that side from invasion by the poison, we none the less obtain in that muscle the characteristic curve at the same moment, and in the same manner, as in the muscle of the other limb to which the poison has been distributed by the circulation. It seems to us, then, that it is well demonstrated that the action of caffeine in these cases is exerted in its entirety on the central nervous system.

We do not, however, mean to affirm that caffeine is not a muscular poison; take, in fact, any kind of frog, whether green or red, and put caffeine directly in contact with the muscular substance, and energetic contracture results, and the muscle become inexcitable. We may also obtain total muscular rigidity in the green frog, and with more difficulty in the toad, by the injection of considerable doses of caffeine in any part of the body. But it seems to us that this mode of action ought practically to be ruled out. It is only obtained, in fact, with doses approaching one gramme per kilogramme of the bodily weight.

Besides the medullary excretion which attends its use, caffeine excites the cerebral motor centers. This conclusion is derived from our experiments on man, and from the analysis of cases of poisoning which have been described. We note, in fact, in the human subject when under the influence of this drug, agitation, and involuntary impulses which demonstrate, so it seems to us, a hyper-activity of the psycho-motor region. This cerebral excitation, in general, is too well known to require that we should insist upon it. We say, however, *en passant*, that we have seen produced in an experiment especially devised for this end, a very marked cephalic vaso-dilatation in a dog weighing twelve kilogrammes, in which we had injected 25 centigrammes of caffeine. As a result of careful observation, then, we are warranted in establishing in reference to the action of caffeine on the motor functions the following mechanism: *The motor voluntary influx starts from the cerebrum with a greater energy, and it acts on the motor spinal centers in a more excitable state.* The consequence of this double action is to diminish the sensation of *effort*, and to banish *fatigue*, which is a nervous and at the same time chemical phenomenon.

But this is not the only action which is manifested. Caffeine facilitates violent muscular labor by a quite different mechanism, which we were, we believe, the first to point out, and which must play an important role in the genesis of the sentiment of *bien etre* which the drug produces.

2. *Caffeine prevents breathlessness and the palpitation consecutive to effort.*

We know since the researches of Oppenheim, that prolonged and repeated efforts may determine a veritable *thirst* for air, a dyspnœa which in its turn augments the organic wastes, while by slow and moderate labor the elimination of urea remains normal.

The experiments which have demonstrated to us this dyspnœa were made on men. We employed the graphic method, which enabled us to appreciate with certainty not only the changes of rhythms, but also the changes of form presented by the respiration and pulse in the course of the experiments. The kind of work which we chose was running—work which very rapidly brings about the circulatory and respiratory troubles which we desired to study, and in which it is easy to measure with sufficient approximation the intensity and quantity by keeping account of the space traveled and the time employed therein.

All our subjects also were young men, from twenty-one to twenty-four years of age, without any cardiac or pulmonary lesions or disturbances. The mean speed was 200 meters per minute, and we marked out for each individual a certain race course which was constant, of such length that after having finished it the runner that had taken no caffeine began to be incommoded by the consecutive circulatory and respiratory troubles. The tracings were taken for the respiration by means of Marcy's pneumograph; for the circulation, by means of two connected drums placed over the two carotids; and both series were begun one minute after the end of the running, this time being necessary for arranging the apparatus. The caffeine was administered in doses of 25 centigrammes in a cup of coffee, which made about 10 centigrammes more. The experiments began two hours after the ingestion of the caffeine, as we found at the very onset of experimentation that this period of time was necessary for the alkaloid to procure its physiological effect. In the first two hours which follow the ingestion, during what might be called the phase of invasion, the phenomena of regulation do not appear, and we note instead a tendency to breathlessness and palpitations.*

The action of caffeine observed in these conditions, in thirty experiments on six different subjects, has given us results which varied in their intensity, but whose significance has been constant. The pulse is much less accelerated; in several cases we found *one beat* more than before the running; while in the same individual without caffeine the same amount of running doubled the pulsations.

It was the same with the respiration, and even here the phenomenon was still more marked. It generally happens that running does not modify the respiratory rhythm in the individual who has taken caffeine, while without caffeine there is a breathlessness which triples the number of respirations.

The subjective state of the runners was naturally in direct proportion to their physiological state. After taking caffeine, it was the universal remark that nothing was felt of that painful oppression which is experienced when such violent exercise is taken without caffeine.

The conclusion which presents itself may be formulated thus: *Caffeine puts a man who has not gone through a course of training in the state of a man that has;* in other words, it communicates, so to speak, instantly, the *training* that is wanted. In a man that has undertaken a regular training, it adds its action to that of the training. We have, in fact, found, notably in the form of the respiration, modifications produced by caffeine similar to those which Marcy has indicated as supervening under the influence of training. There is no need of insisting on the importance of these results.

CAFFEINE DURING INANITION.

The foregoing study has furnished a satisfactory explanation of the excito-motor properties of caffeine acting on a subject normally nourished. It is an over-activity of the motor system, an augmentation of the muscular tonus, which, joined to a regulating of the circulation and of the respiration, explains the considerable aptitude for physical work which attends the use of this substance. We have shown, principally in the analysis which we have made in frogs, that it is this nervous excitation which constitutes the essential phenomenon of caffeine poisoning.

And now, to explain the aptitude for work which caffeine produces in the fasting individual, shall we have need to seek for another physiological property, or shall we be able, by the analysis of the facts, to bring the second phenomenon under the first, as we would include a particular case under a general head? The accumulated facts, indeed, suffice for this study, on condition that we criticise them and interpret them properly—on condition, especially, that we start from a well determined basis, that is to say, from a suitable analysis of the conditions of muscular work, and their relations to the state of inanition.

The view which first sprang from facts, the nature of those which we relate in this work, was that of a tissue-saving action (*action d'epargne*) proper to caffeine. We found this opinion clearly expressed from the moment when the inquiry was first put.

In 1850, M. De Gasparin made to the Academy of Sciences a communication which is still celebrated, in which he studied the dietary of the Belgian miners of Charleroi. The doctrines of Liebig were then in full blossom.

M. De Gasparin, analyzing the daily ration of these miners, found there only 15 grammes of nitrogen, and inquired how, with this feeble proportion of nitrogen, scarcely superior to that of the religious orders devoted to asceticism, these men could perform every day a considerable amount of labor.

"The explanation," he says, "is found in the fact that the miners of Charleroi consume a great deal of coffee, and it is this coffee which enables them to consume less nitrogen. The analyses of Boeker show that the excretion of urea is diminished by coffee; this substance prevents denutrition, and consequently the daily needs are diminished."

At the same session of the French Academy, the great physiologist, Magendie, made grave objections to this theory.

"It is inexact," he said, "to believe that one can measure the alimentary value of a ration by the number of grammes of nitrogen which it contains. These miners consume daily, it is true, a feeble quantity of azotized substances, but with this they ingest a considerable quantity of ternary aliments. What right have we to say that it is not by means of these aliments that they work?"

Physiologists became divided into two camps, and the dispute continued as to whether or not coffee and caffeine have a saving action on the tissues. The greater part of the researches have pertained to the variations in the quantity of urea excreted daily, accordingly as the subject had or had not taken caffeine. Is this quantity augmented or diminished? On this there has been a wide divergence of views.*

A third series of experimenters, at the head of which we must place Voit (1860), denied to coffee any characteristic action on the excretion of nitrogen.

It is with this last opinion that we are obliged to side as the result of experiments. Our personal researches, in fact, although not very numerous, have given us from the point of view of the excretion of nitrogen variations so wide apart that we have not been able to establish any rule; these researches pertained to dogs and men. The detailed, critical examination of the works which we have just cited has led us to the same conclusion.

It is not possible, in fact, that the numerous experimenters who have found a diminution of urea could have been all mistaken.

We have not been able, in reviewing their experiments, to hit upon any constant source of error. On the other hand, the researches which point to an excess of urea, particularly those of Roux, of Fubini, and Ottolenghi, seem to us equally irreproachable. The conclusion, then, which forces itself upon us is the following:

"*Caffeine has no specific action on the excretion of urea; it modifies this excretion in different senses under the influence of unknown conditions.*"

Do we mean by the above that we have nothing to say as to the action which caffeine has on the excretions? By no means. We find here, under another form, the objection which Magendie made to the theory of *tissue saving*, when that theory was first broached. We may even to-day go farther. We now know well, since the famous experimentation of Fick and Wislicenus and all the labors which have followed, that muscular work derives its force from the chemical energy, not of the albuminoids, but of the ternary compounds of the organism—fats, carbo-hydrates, and especially of the glycogen of the muscle itself, as Chauneau has shown. It is, then, this consumption which interests us most, particularly from one special point of view.

Here we find a satisfactory agreement in the experiments. Two methods have been employed; the one indirect, consisting in observing the variations of the temperature, the other direct, *i. e.*, by measuring the carbonic acid set free in respiration.

The first method seems to have given contradictory results, but these, when critically studied, agree fairly well. We have, in fact, two orders of observation: 1. On rectal temperatures taken in the dog. 2. On temperatures taken in the human subject.

The first indicate in a constant manner that caffeine raises the temperature. The very precise researches of Binz on this subject seem to us particularly worthy of attention. He has seen caffeine raise the temperature more than one degree, and our personal researches fully confirm this result. On the other hand, the temperatures taken in man indicate, in general, a slight fall; Marvaud, who has made numerous researches on this subject, finds a fall of temperature amounting to three-tenths of a degree. But we must remark that these researches, as well as others of the same order, are vitiated by the fact that the temperature was taken in the axilla, where the temperature must be considered as peripheral; and Leblond, in researches made with care, has noted that caffeine lowers the peripheral temperature, considered in its relation to the central temperature. This peculiarity, moreover, accords well with the vasotonic action of caffeine. Leblond, also, by observing the buccal temperature, which comes much nearer to the central temperature, noticed no variation under the influence of caffeine.

This indirect method of thermic observation leads us then to admit an increase of combustion. The researches on the excretion of carbonic acid are, unfortunately, not numerous; we have found only two series—that of Hoppe-Seyler (1857) and that of Edward Smith (1860). It would, without doubt, have been interesting to verify these experiments, already old, but as they emanate from observers of the highest competence, and agree among themselves, they are deserving of great confidence.

This is a *resume* of the experiments of Hoppe-Seyler:

A little dog took every day a small dose of caffeine (1 to 4 decigrammes), in all a little more than a gramme. During this time, with the same food, the quantity of urea varied so little that the writer did not think it worth while to make any account of it. The carbonic acid secretion was increased from 11·41 to 13·28. This was the mean of eighteen researches of about sixty minutes' duration.

These are the conclusions of Edward Smith as the result of experiments on man:

Tea produces augmentation of two to three grains of carbonic acid per minute. The maximum effect is seen at the end of twenty-five to forty-five minutes. It is equally efficacious when taken cold, and when long infused. "Caffeine is an excitant of the nervous system, but to a less degree than tea."

We may then conclude that the carbonic acid excretion is augmented.

If, now, we take up as a whole the question of combustion as pertaining to the ternary materials, we find a series of facts perfectly harmonious and coherent from a physiological point of view.

Our experiments, and those of our predecessors related in the first part of this article, have led us to the conclusion that caffeine produces excitation of the motor part of the cerebro-spinal system, whence arises an augmentation of the muscular tonus. Now, we will know to-day that it is in the muscles that the greater part of the combustion of the economy takes place, that this combustion pertains to the ternary materials, that the intensity thereof is regulated by the nervous system, which increases or slows accordingly as it augments or diminishes the muscular tonus, and, lastly, that it is by this mechanism that the nervous system presides over the regulation of the temperature. These laws being established, it would, *a priori*, be inferred that caffeine, which increases the muscular tonus, would cause the temperature to rise, and would augment the exhalation of carbonic acid. These two orders of ideas mutually support each other, and form a perfectly coherent whole.

* See the excellent thesis of Parisot, March, 1889.

* On summing up the opinions of physiologists who have experimented with caffeine or with some one of the natural products which contain the principle, the writers find about as many that support the negative as the affirmative of the question.

By the side of these two kinds of researches, each having a bearing upon one element of the question, it is necessary to examine those which have considered the question *in toto*, *i. e.*, to see if an animal subjected to fasting loses more or less of its weight and succumbs more or less quickly to inanition accordingly as it receives caffeine or not. On this subject we find an interesting remark in Hoppe-Seyler *apropos* of the experiment cited above.

"Despite an abundant supply of food, the dog had lost at the end of the experiment about three per cent. of its weight."

Likewise, Edward Smith says that he has observed several remarkable cases where tea, added to the ordinary regimen of prisons, produced a diminution of the weight of the body.

Guimares and Kaposo attacked the question directly. They subjected dogs to fasting, allowing them all the water they wanted to drink; two of them received, besides, a certain quantity of infusion of coffee. These two died quicker than the others.

We have repeated these experiments, modifying them in the following manner to place muscles as far as possible in irreproachable conditions. We never allowed the fasting to go on to the death of the animal. It is known that nutrition is not the same at the commencement of the period of inanition as at the extreme limit, and we took care not to exceed the first period. We employed dogs as the subjects, and studied fasting without and with caffeine. In this way we eliminated the individual differences. The dose varied from one centigramme per kilogramme of the weight of the animal (a small dose) to five centigrammes, a dose which produced an energetic excitation.

In these conditions we did not observe in the weight of the body variations which could be attributed to the caffeine. From this synthetical point of view, then, we find no *action d'epargne* (tissue saving). We deny, then, to caffeine the property which has been attributed to it in different degrees of maintaining the organism in its integrity, despite inanition.

We arrive at this final conclusion:

Caffeine augments the wastes in carbon, and does not restrain the other wastes.

It belongs to us now, with this experimental fact, to explain the tonic action of caffeine on a subject under inanition. We shall abandon the theory of Payen that caffeine is a powerful aliment because it is very rich in nitrogen, and content ourselves with remarking:

1. The doses of caffeine which produce the effects which we have been studying are ridiculously small for an aliment (several grains only *per diem* for a man).

2. The tenure of a substance in nitrogen in nothing prejudges its alimentary value for the animal. Urea is more rich in nitrogen than caffeine; is it an aliment?

3. Caffeine passes out unaltered in the urine. We find ourselves, then, in the presence of a seeming paradox.

Caffeine on the one hand promotes denutrition; on the other, it prevents the injurious effects of fasting.

We shall easily succeed in explaining this phenomenon if we take care to distinguish two cases which seem to have been confounded.

It is one thing to resist inanition a long time when maintaining repose, it is another to perform physical or mental work when fasting for a day or two. Now, it is the latter of the two alternatives that we have in view.

The condition for resisting inanition is to reduce waste to the minimum, if one has to pass a considerable time without food but in inaction; it is in reality, in this case, a waste-restraining action that is wanted. Cold-blooded animals, whose activity is much less than the warm-blooded, resist inanition ten times better than the latter; likewise among the mammals, those whose chemical activity is the greatest succumb the most quickly. We find conditions where the resistance to inanition is enormous, and where the saving of tissues is at its maximum—we refer to hybernation. Now, in this case, what do we see? Absolute immobility, profound sleep suppressing not only the activity of the muscles, but also that of the senses, slowing the respiration and the heart, that is to say, little expenditure, but also no work.

Now with caffeine we obtain just the reverse, *i. e.*, an extensive work; we can, however, obtain it only at the price of the wear and tear of the organism. The law of conservation of energy applies here as everywhere. The animal machine will perform its functions only by consuming combustibles, and it is precisely by energizing combustion that caffeine permits muscular labor during fasting.

We cannot stop to consider metaphysical theories, such as that of medicinal fulminates, according to which, caffeine furnishes to the organism a potential energy accumulated in itself, and which is transformed by the organism into work. This is but playing with words. Caffeine acts on the fasting animal just as it acts on the animal that is fed; the action is identical, and it is the external appearance only of the phenomena which has led physiologists to believe in a special property of caffeine which enables it to replace aliments. It replaces them only from one point of view. We refer to the point of view of the general tonic excitation which the ingestion of alimentary substances produces.

Consider, in fact, the case of a man who performs some kind of work, who is walking for instance: At the end of a certain time there appears in him that state which we call hunger, *i. e.*, with certain special sensations localized in the stomach; he experiences a general enfeeblement; his legs refuse to carry him; it requires an effort of the will to place one foot before the other, an act which he just before accomplished automatically, almost unconsciously; if it is necessary for him to make a greater effort, to leap over a ditch, to climb a tree, he cannot accomplish it at all readily; the heart is slowed, the pulse is small. Suppose now that he eats something. As soon as he has introduced into the stomach a small quantity of food, the discomfort disappears; the vigor and trim return; the pulse regains its amplitude. The sense of well-being is almost instantaneously felt with the ingestion of the first mouthful, especially if the food is warm; the man can now almost immediately resume his walking.

On analyzing this case, let us see what we find: When hunger is felt and has arrested work, it is not because the substances which furnish the energy necessary for this work, fat, glycogen, etc., are exhausted, and the ingested aliments have not renewed these reserves. In fact, it is the very ingestion of aliments that has revived the failing forces; the effect was produced not only before the food was absorbed, but even before it had commenced to be attacked by the gastric juice. It can only be, then, a nervous action with which we have to do here. We know not what part to attribute to the peripheral excitation consisting in buccal, gustative, and stomachal sensations which make themselves felt on the nerve centers to heighten the tone, nor what part to attribute to the immediate absorption of a very small portion of the aliments immediately soluble and absorbable, such as dextrines, sugars, peptones, etc. It is possible that these two processes co-exist, and both conduce to the effect. It is not the reconstitution of the reserves which enables the man to resume his work, as in the case of the locomotive which takes on water and coal, for the aliments ingested will not be utilized till later; but their ingestion enables the worker to utilize immediately the residue of previous reserves.

The cause, in fact, of that enfeeblement which is an integral part of the sensation of hunger is that the organism, by an instinctive adaptation of itself, restrains its activity and condemns itself to repose in order to diminish the wear and tear of its substance, and to better defend its integrity against inanition.

The researches of physiologists on inanition have taught us, in fact, that, from the very commencement of fasting, the rate of exchanges undergoes a large diminution. The temperature falls several tenths; uric and carbonic acid are excreted in less quantity. As to carbonic acid, for instance, Edward Smith has found the quantity lessened 25 per cent. Ranke, Hanriot, and Richet have given similar figures. The mechanism by which is produced this inhibition of chemical actions consists evidently in a sort of cerebral *engourdissement* or torpor. As it is the nervous system which by its activity regulates that of the organism in general, and as, on the other hand, the nervous system is much more sensitive than any other part of the body to the variations of the internal or external environment, it is this which is first affected; and as soon as the blood begins to be impoverished and the reserves diminished, unless there supervenes some cause of excitation, the organism is brought by the higher nervous influence into that state of atony where effort is impossible, though it may still be in a good condition to long resist inanition. If the latter continues too long, after all the reserves have been consumed little by little, there comes a moment when the nervous system is attacked in its turn by denutrition, and then the final break-down is inevitable; the loss of weight, previously slow, now rapidly increases, and death ends the scene.

But at the beginning of the period of inanition, we see the organism realize of itself that sparing of the tissues which some have attributed to caffeine; it is this very sparing action which is the obstacle to work, and it is by energizing denutrition that caffeine restores activity.

If, in fact, we admit, as has just been set forth, that the ingestion of aliments acts as a stimulant to the nervous system, it is an easy matter to admit that it is possible to substitute one stimulant for another. We know, in fact, that during famines uncivilized populations have recourse to the ingestion of substances which are not alimentary, as the bark of trees and clay. It is plain that this artifice may do good by the mechanical excitations which it produces along the digestive tube; for a stronger reason, it is easy to understand that caffeine, with the excitant properties which we have found it to possess toward the nervous system, may have the power to arouse the latter, restore its activity, and—by its intermediation—that of the muscles; and thenceforth the organism goes on burning its store of reserves and transforming their physical energy into work. Evidently these reverses will eventually be exhausted, and the harder the work, the sooner this will happen. And if alimentation is not re-established, death will come about quickly. This is what was noticed in the experiments of Guimares.

In support of our theory we will consider two necessary orders of facts, where the activity during inanition is equally maintained intact, or even excited, and where the denutrition is evident. The first of these is the action of cocaine. We have seen, in the introduction to this article, that coca is employed in certain countries in the same way as the caffeine plants in others. Now, cocaine produces a hyper-activity of the combustions so great that one may say that it produces fever. As for fever itself, which constitutes the second order of facts of which we desire to speak, its denutritive action is too well known to need demonstration, and everybody knows that febricitates have no disposition to take food, and that despite prolonged fasting their activity is excessive. The comparison of these two cases with the action of caffeine seems to us to be appropriate here.

RESUME.

1. Caffeine in small and repeated doses, about 60 centigrammes a day (which may be prescribed with advantage to soldiers on the march), facilitates muscular work in augmenting the activity, not directly of the muscle itself, but of the motor nervous system, cerebral as well as medullary. The consequence of this double action is to diminish the sensation of effort, and to avert fatigue, which constitutes a nervous and at the same time chemical phenomenon.

2. Caffeine prevents breathlessness and palpitations consecutive to effort, which is of great importance.

3. It thus immediately communicates to a man who gives himself up to violent and prolonged exercise the aid that he requires.

4. In producing this excitation of the cerebro-spinal motor system, on which depends the augmentation of the muscular tonicity, the caffeine augments the waste of the carbon of the body, and particularly of the muscles, but does not restrain the nitrogenous waste. It, therefore, is not, in the strict sense of the word, a means of saving (*moyer d'épargne*).

5. A saving action in general can take place in the higher animals in a complete manner to prevent the injurious effects of fasting, only in a condition impossible to realize, namely, inaction or immobility, more or less absolute, where there is little expenditure without work. With caffeine we observe just the reverse, that is to say, intense work, which we will obtain only at the expense of the wear and tear of the organism. The animal machine can work only in consuming combustible matters, and it is precisely in promoting this combustion that caffeine permits muscular work even during fasting.

6. Caffeine has not, as is generally believed, the marvelous property of replacing food; it only replaces the general tonic excitation which the ingestion of food produces. It is admitted that it is the direct and instantaneous action of the aliments which stimulate the stomach and nervous system, and that their alimentary value is at first nothing; one might substitute one stimulant for another. Caffeine, far from sparing the reserves, will place a fasting man in a position to undertake his work only by attacking these reserves, the destruction of which it hastens by the excitation of the nervous system, and by its medium that of the muscles; the organism will then soon use up its nutritive supply, and the caffeine will not prevent it. It is, nevertheless, of incontestable but temporary utility for the physical forces.

AFRICAN INSECT WAX.

By J. R. Jackson, Curator of the Museums, Kew.

The production of insect wax in some countries forms an important branch of commerce, notably in China, where upon the branches of *Fraxinus chinensis* and an allied plant, *Ligustrum lucidum*, wax is produced in very great abundance, to such an extent, indeed, as often to completely cover the branches with a thick white incrustation. The insect which causes this deposit is the *Coccus Pe la*. The wax, which when fresh is almost as white as snow, and is easily scraped from the branches, is cleared of all impurities by melting and straining, and is employed for making candles, which are used at funerals and for festive occasions, such as wedding ceremonies, etc. Here, then, is a well known commercial commodity among the Chinese, the origin of which is partly vegetable and partly animal. Similar substances occur in other countries, which, if more attention were given to them, might be utilized. Even the dreaded "Australian bug," or, as it is now known, the fluted scale insect (*Icerya Purchasi*), which has become such a pest of late years to many useful plants in New Zealand, California, and South Africa, might perhaps be turned to profitable account, and the creature would thus cease to be the pest which it is now considered. In some parts of the Cape Colony the orange culture has suffered severely from the attacks of these insects, while a similar misfortune has befallen those in New Zealand and California. But the insect is not at all particular in the choice of plants upon which to make its home, besides which it is extremely prolific, and, added to this, it is said that its abundant waxy excretions protect it from the action of insecticides. That this waxy substance is abundant is readily seen by placing one of the insects on a piece of glass and heating it over a lamp, when nearly the whole of it melts away.

These thoughts of the more general utilization of wax or fat producing insects are brought to mind from the fact of a peculiar kind of wax having been shown to me by a member of the staff of *The Chemist and Druggist*, who had recently received it from a friend in South Africa who had found it in Damaraland, where he described it as being used by the natives as a cement for calabashes (water vessels, etc.). To prepare it, he says, it is exposed to the sun to partially melt or soften, when it is used to fill up cracks—apparently like putty—and as it hardens it forms an almost unbreakable cement. This peculiar substance is the product of an insect, and, though apparently common in Africa, is comparatively unknown out of that country.

In the Kew Museums are samples of this wax, both in the natural state and melted and formed into balls; in the former condition it occurs in small irregular pieces, usually about the size of a pea, but sometimes in large agglomerated masses, composed of a number of such pieces. Some, however, are of a lengthened vermicular form, incrusting the spiny twigs of the mimosa upon which it has been formed. Many of these fragments have much the appearance of a caterpillar, and the whole of them are of a dirty white color.

One sample in the museum at Kew is labeled "Gian," or insect wax, from Natal; while another specimen is said to be from a species of mimosa, though the wax is by no means confined to this genus of plants, being found on a number of other trees. It is said to be well known all over South Africa, and to be met with in considerable quantities in Natal. It is the staple used by the Zulu warriors for the making of head rings, and it takes a very fine polish. It is stated that in passing along a road it is quite a usual sight to meet with two or more ring men sitting by the side of the road giving each other a friendly touch or polish before entering a town, village, or kraal, much the same as we should employ a shoeblack. A Zulu so employed is shown in the accompanying engraving, which is from a photograph.

As it is stated that any quantity of the wax is procurable in Natal, it would be quite worth the while of some manufacturer to test its capabilities, when we might also hope to discover the insect which causes it. —*Chem. and Drug.*

THE BRIDGE OF MATCHES.

A BRIDGE stretching over a space of at least four inches may be easily constructed with the common an-

FIG. 2.—ELEVATION.

gular parlor match by following the directions here given.

Place match No. 1 upon the table (see plan, Fig. 3), place upon it the extremities of Nos. 2 and 3, and lay No. 4 crosswise upon the two latter. Lift No. 1 with the thumb and forefinger of the left hand, and slip in

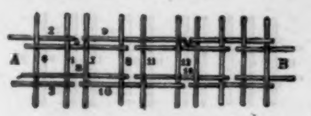


FIG. 3.—PLAN.

Nos. 5 and 6 with the right hand. Through the effect of the levers, the whole should form a portion of an arch which will stand upon the table. Place No. 7 crosswise upon 5 and 6, and No. 8 upon the two other ends of these same matches, 5 and 6. Lift No. 8 carefully in order to place Nos. 9 and 10, whose left ex-

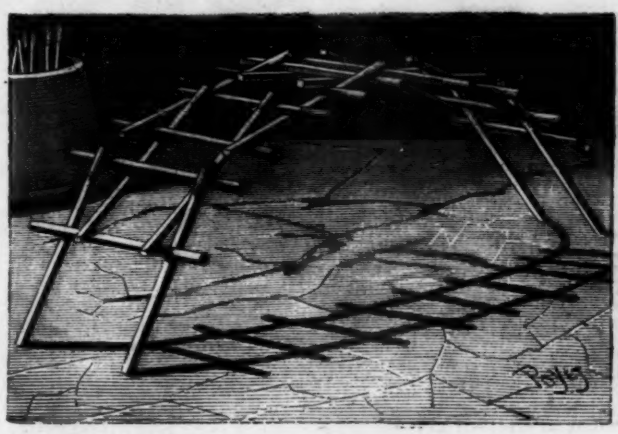


FIG. 1.—BRIDGE OF MATCHES.

tremities will bear upon No. 7 after passing under No. 8; and continue the operation until the arch has reached the desired length.

SCIENTIFIC OPPORTUNITIES.*

By Prof. OLIVER LODGE, D.Sc., LL.D., F.R.S.

WE meet here as a working society of members, all alike interested in physical science and willing to study seriously the enormous groups of phenomena which that term covers. Our subject is a most enticing one, but it is alarmingly huge. No man can pretend to be equally familiar with all parts of it, and with all its border sciences. Yet, to be a complete physicist, that is what is demanded. As the German proverb says, "Ein Physiker muss Alles kennen," and the hopeless impossibility of satisfying such a demand ought to brace us to fresh effort rather than to unnerve us with slackened energies. Such a demand, moreover, has the happy equalizing effect of the theological doctrine of original sin and free grace: it makes us all alike incompetent and unworthy, and since no man is able to proclaim himself a complete physicist, every man who takes up and works at one corner of it may hope for some result from his labors, if he pursues them in a patient and candid and undogmatic spirit. With those persons—paradoxers, as De Morgan called them—who, on the strength of a few ill-considered notions, propose to reconstruct the universe, and to flout their conceited ignorance in the face of the great searchers after truth of all eras; with them, I was going to say, we have no patience. But patience one does have with them nevertheless, for they are frequently unhappy and misguided men, not without a certain ability, possessors often of a very enviable energy; men who, if rightly self-directed, might have accomplished something, but who, by reason of some trivial crank, continue all their lives to batter themselves fruitlessly against the hard wall of opposing fact, flattering themselves that they are attacking a malicious combination of unprincipled scientists, banded together in league against them.

Such are the men who say that the earth is flat, that electricity and heat are identical, that water is only a form of energy, that the circumference of a circle is commensurably related to the diameter, and so on. Men, again, who assert that they have discovered a new force, and that the nature of electricity has revealed itself to them, after reading some three-and-sixpenny text book on the subject. Such persons should be informed that what they have found in an elementary text book is but the A B C of the subject, and for them to presume to have a first hand opinion on it is as absurd as if a person who had read nothing but a few pages of English grammar should propound opinions on English literature, and write an essay on the works of (say) Mr. Browning. Not such, however, are the men who ever advance science. The unprofessional workers are patient, humble men, who grope their way, occasionally by means of mathematics, more often by means of experiment; searching diligently and recording their results, guided by instinct often more than by knowledge, knowing indeed it may be very little, and making many mistakes, but perseveringly amending their methods and devising fresh ingenuities of attack. To some of these it is occasionally given to discover secrets hidden from the wise and prudent. A trained mechanician, for instance, has immense advantages in the command of tools and weapons of investigation. Such workers have often a deftness of hand, a keenness of eye, and a delicacy of touch which those who have had more time and opportunity for study have good cause to envy. And their very lack of a wide outlook, by leaving them leisure and will to concentrate attention on one small corner of the field, may result in their detecting treasure unsuspected by the man of broader views. Continually it has to be noticed that the most novel and surprising facts are discovered, not by the man of learning, who is apt to be over-weighted by his stores of information and to move rather cumbrously in unexplored territory, but by the light skirmisher or adventurous explorer, who penetrates with apparently inadequate equipment into wilds and thickets regarded as scarcely penetrable by the more completely panoplied general of modern science.

I will now see what useful suggestions I am able to make concerning fields of work lying open to the explorer at the present time. Needless to say that those I do not see or at the time think of are more numerous by far than those I mention, but, standing up and looking about, I see a number of likely-looking avenues which may lead to something if followed up; all that is needed being a good head, patient labor, and persevering skill to bring facts to light now only dim and unknown. Some of these avenues I will now do my best to point out; and though, no doubt, some are blind alleys if pushed into straight ahead, it is wonderful what side issues and unexpected openings present themselves when once you have set out on a quest. This is the great advantage of a study of nature. You may, by ill luck, start with erroneous ideas, and may be aiming after something impossible to attain, but if you keep your senses open by the way, the things you will unexpectedly hit upon turn out far more interesting and really valuable than the chimera in quest of which you started.

Running over some of these open paths, we come across a fruitful field in a study of the effects of light on a great number of things. That light affected chemical combinations has long been known, and it is the foundation of photography, but we now find there is scarcely anything which light does not affect. It affects selenium enormously, bringing down its electrical resistance to half or one-third what it is in the dark. It may affect other bodies in a similar way. It affects metals, charging them electrically in a curious way, especially such metals as zinc. It seems to disintegrate or evaporate surfaces long exposed to it. It affects the electric field, causing a short spark to occur much more easily in ultra-violet light than in the dark. And quite recently, by Mr. Shelford Bidwell, it has been found to affect the magnetism of an iron rod in a sensitive condition. Of none of these phenomena has the investigation more than begun. Then, in the region of photography, there is a good deal to be done not only in understanding the photographic process itself, but in photographing rays hitherto intractable. The photography of ultra-red rays a good way below the visible spectrum is, so far as I know, in the hands of Captain Abney, who discovered how to do it. But others should now take it up and develop it. Celestial photography, with plates sensitive to obscure rays, might reveal a number of unsuspected and invisible semi-cool worlds. The electric spark has lately been a favorite subject for photography, and much good work may be done by obtaining judicious photographs of lightning on fixed and on moving plates. A double-nozzled camera, with two plates, one fixed, the other spinning rapidly on an axis perpendicular to its plane (kept spinning at an approximately slow speed, say by clockwork), so that the same flash is depicted on both plates simultaneously, would give much valuable information. For some flashes, a very moderate speed of rotation, or even a waggling camera, suffices, but for others a speed of 30 revolutions a second gives an image apparently the same as if the plate were still. What is known as the Hall effect in various substances has not yet been exhaustively observed or measured. It has not even been observed as yet in insulators, though it ought, one would think, to be there: nor has its connection with the Faraday effect, the rotation of the plane of polarization of light by magnetism, been at all satisfactorily or finally made out, while its discrimination from, or assimilation to, certain known thermo-electric facts is at present hanging in suspense. Perhaps, however, these matters are rather too complex to be suitable for mention under present circumstances.

A simpler and more qualitative research is the effect of magnetism on a number of things; for instance, on living organisms. A person in a magnetic field is not known to feel anything. Reichenbach thought he had found people who were optically sensitive to a magnet, so that they could see whether an electro-magnet is excited or not. It may be so, but subsequent observation has not gone to confirm it. But, even if all persons are insensitive (by no means a likely conclusion without experimental proof), other animals may not be. Phosphorescent things—a glow worm, or some of the luminous sea beasts of Dr. Herdman—may be fit subjects for experiment. How, again, does a gymnotus or electric eel behave in a powerful magnetic field? I can imagine a fine field for a physicist to encamp on Puffin Island, under the auspices of the Biological Society, and bully some of the microscopic and other animals with electric and magnetic and optical appliances. Even if they declined to take any notice, the fact ought to be ascertained, but if any of them were properly sensitive, development of the fact might be surprising. Then, again, plants: sensitive and other muscular plants are well known to set up electric currents and to be under electric control; magnetism might be applied to plants also, and about their electric phenomena there is much more to work out. Heaps of experiments on plants and on germinating seeds could be made by an ingenious physical experimenter, and, though they might be more sluggish in their response than animals, some remarkable development might ensue. A change of physical surroundings in the course of a few generations might bring about noteworthy changes of structure. Seeds growing under inverted circumstances as regards light have, I suppose, already been experimented on. I do not know. I am not familiar with the subject, and the biological suggestions I throw out are therefore vague. But this I feel, that so long as the origin of life is wrapped in mystery, experiments on the simplest form of protoplasm—subjecting it to a variety of kinds of circumstances, electrical, magnetic, optical, thermal, mechanical, and chemical—may any day, though not perhaps for a few centuries yet, result in an astounding discovery, which will throw our present idea of evolution into the shade.

A number of experiments and observations can also be made on crystals and crystal formation by those who have suitable opportunities. The accidental formation of twin crystals, and the beautiful optical phenomena which develop themselves at the twinning surface, are matters of quite recent discovery, or, at least, of recent attention. So also is the perfectly astounding fact that a crystal, such as Iceland spar, for instance, can be mechanically twinned or pushed over into its perverted form by the pressure of a knife judiciously applied. Effects of magnetism on chemical action have now been discovered, and it is known that a piece of magnetized iron is less easily attacked by an acid than ordinary iron, provided, at least, the iron is pointed so that its lines of force are very diverging, or its field rapidly varying. But many other facts remain to be ascertained in connection with these subjects. The electrical properties of flame are only partially worked out, and their power of discharging static electrification has had fresh light thrown on it quite lately by some experiments of Worthington. The study of phosphorescent substances is yet in its infancy. Why should not a phosphorescent substance give out a really useful amount of light? What is the process by which the glow worm maintains so brilliant a speck of illumination?

Many amateurs possess an induction coil, having indeed often made it themselves. Approximately the same number of amateurs do not know what to do with it when made. They use it to illuminate vacuum tubes, which they buy at a shop, nicely colored. Well, don't buy them, but make them, and omit the colors. Read the researches of Mr. Crookes, and other more recent investigations on the subject by Schuster, and Moulton, and E. Wiedemann, and others, and you will find in the electrical phenomena of high vacuum an unlimited field for profitable experiment. More than this: a whole continent of practically unexplored territory has just been opened by the discovery of Hertz that electro-magnetic waves in air can be easily produced and detected. Some may know and some may not know of these brilliant investigations into the propagation of electro-magnetic waves. To those who do not know I can give no idea in the course of this address. I am dealing with them in my evening course throughout next term. But any one with an induction coil, an empty room, and some bits of metal can repeat many of them. And repetition of known experiments is the natural prelude to the discovery of new ones. The Hertzian receiver is a microscopic spark gap. This serves, but it is by no means necessarily the best, as it is certainly not the most metrical method. Gregory has tried a kind of metallic thermometer with some success. In Germany, I hear a kind of bolometer or wire resistance thermometer has been successfully used. Quite lately, Fitzgerald writes me that a galvanometer in circuit with a simple wire makes these waves apparent. This will simplify their investigation very much. That is always the way. Once a thing has been done, hundreds of ways of doing it turn up. For instance, the telephone. The transmission of speech by electricity seemed a mighty achievement, and so it was; but now, almost anything will transmit speech—a flower pot full of cinders has been made to talk. The great electro-magnetic waves excited by any kind of electric discharge are now under easy control, and they can be reflected by mirrors, refracted by prisms, concentrated by lenses. They can be polarized and analyzed. Diffraction and interference effect can be detected in them. Everything optical has its counterpart in this new region, for they are to all intent and purposes light; as Clerk-Maxwell predicted nearly a quarter of a century ago, from refined and abstract mathematical investigation.

The whole of this great field now lies open to the explorer, and only a few have entered it. Here and there a mathematician, here and there an experimentalist, is at work upon it, but there is plenty of room, and every fact is of interest. These electric waves have been obtained as long as 2,000 miles and as short as a foot; they can easily be lengthened, they cannot so easily be shortened. If shortened to the 10,000th of an inch, they would affect the retina and be visible. At present they belong to the region of the infra-red. Whether they affect the human frame at all is unknown. Apparently they do not, but further experience may

* Presidential address to the Liverpool Physical Society, delivered at the inaugural meeting, December 16, 1889.

show that they do. Here also is a scope for observation. This is a good era for the formation of a physical society. That there is no time like the present is true, and true always, but it has been doubly true in science during this nineteenth century. Abused we have been, much of our work has been divorced from art and culture, and some of our works are hideous. The fog-horns with which we shall shortly frighten in the new year are unspeakable: but, for better or worse, the nineteenth century has been the century of science. Never has there been such an increase in knowledge in material achievement; never have so many secrets of nature been unveiled. We inherit the fruits of all this labor, we live encompassed by it—by the evil as well as the good—the smoke-canopied, over-crowded, and squalid towns, as well as the bright and beautiful ideas which this century is responsible for; and it remains for us to enter the twentieth century, not abandoning the good, but doing our best to remedy some of the evil, and to hand on the at present rather smoky torch of science burning the clearer and the brighter for our life and work.

THE ALASKA SEAL INDUSTRY.

The U. S. S. Rush lately sailed from San Francisco to the Alaskan Islands, commissioned to arrest all vessels unlawfully engaged in taking seals.

A recent number of the *London Graphic* contains some interesting sketches pertaining to this industry which we here present.

Of the seals, the females are only about one-fourth the size of the males, and the skins of the young males are the most esteemed. One of these drawings (they are by Mr. H. W. Elliott, the United States Commissioner) represents men driving the seals inland toward the village, where the larger males are shot and the others clubbed to death. The other of these drawings represents a "rookery" on the Pribylov Islands, the chief breeding place of the seal from which ladies' jackets are made. The seals do not stay there all the year round, but come from all parts of the Pacific. In the month of May the males arrive first; the females then follow, and, soon after landing, give birth to their "pups." All the seals leave in October. On St. Paul's, one of the group, about a million young seals are born each year. By law, the killing is limited to 100,000 each year. Nine tenths of the whole take is sold in London. All the dressing is done in England or Belgium.

ARTESIAN WELLS IN KANSAS AND CAUSES OF THEIR FLOW.*

By Robert Hay, F.G.S.A., Junction City, Kansas.

There are wells yielding artesian flow of water in many parts of Kansas. The following may perhaps be considered the principal places:

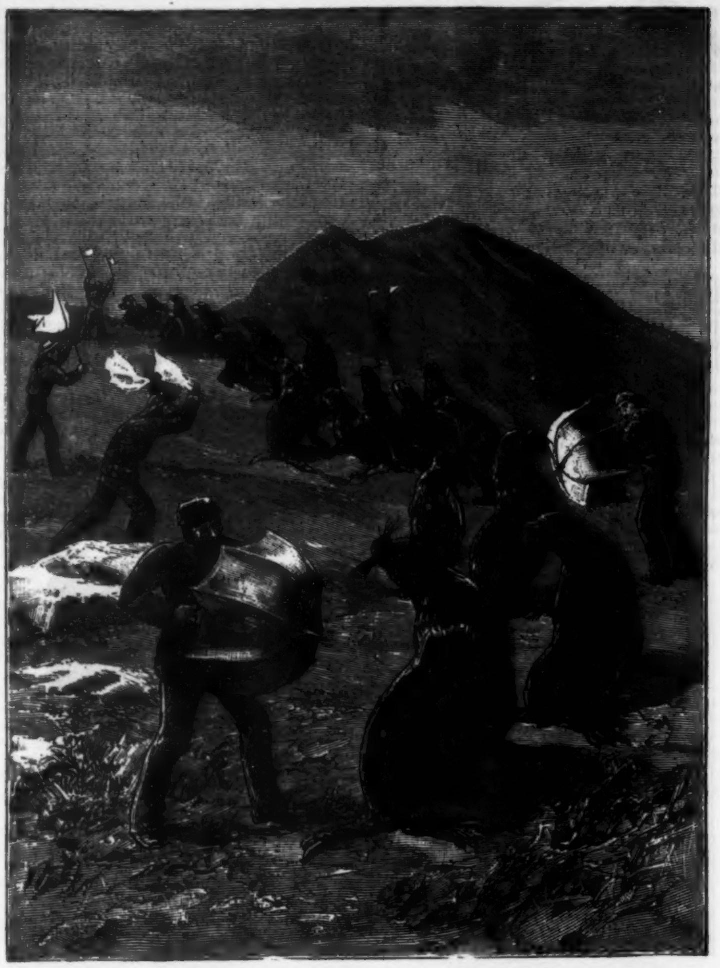
Fort Scott in Bourbon County, Mound Valley in Labette, St. Mary's and Wamego in Pottawatomie, Lawrence in Douglas, northwest of Alma in Wabaunsee County, at the east line of Cloud County, Oberlin in Decatur, near Great Bend in Barton, Larned in Pawnee, on Crooked Creek in Meade, at Richfield in Morton, and Coolidge in Hamilton County.

These wells are of all depths, from less than fifty feet to six hundred and more. The water comes from rocks of different geologic periods. It is of very different kinds, from soft water, pleasant for domestic use, through others of moderate hardness, to some that are highly mineralized and of more or less medicinal quality. Some are decidedly saline.

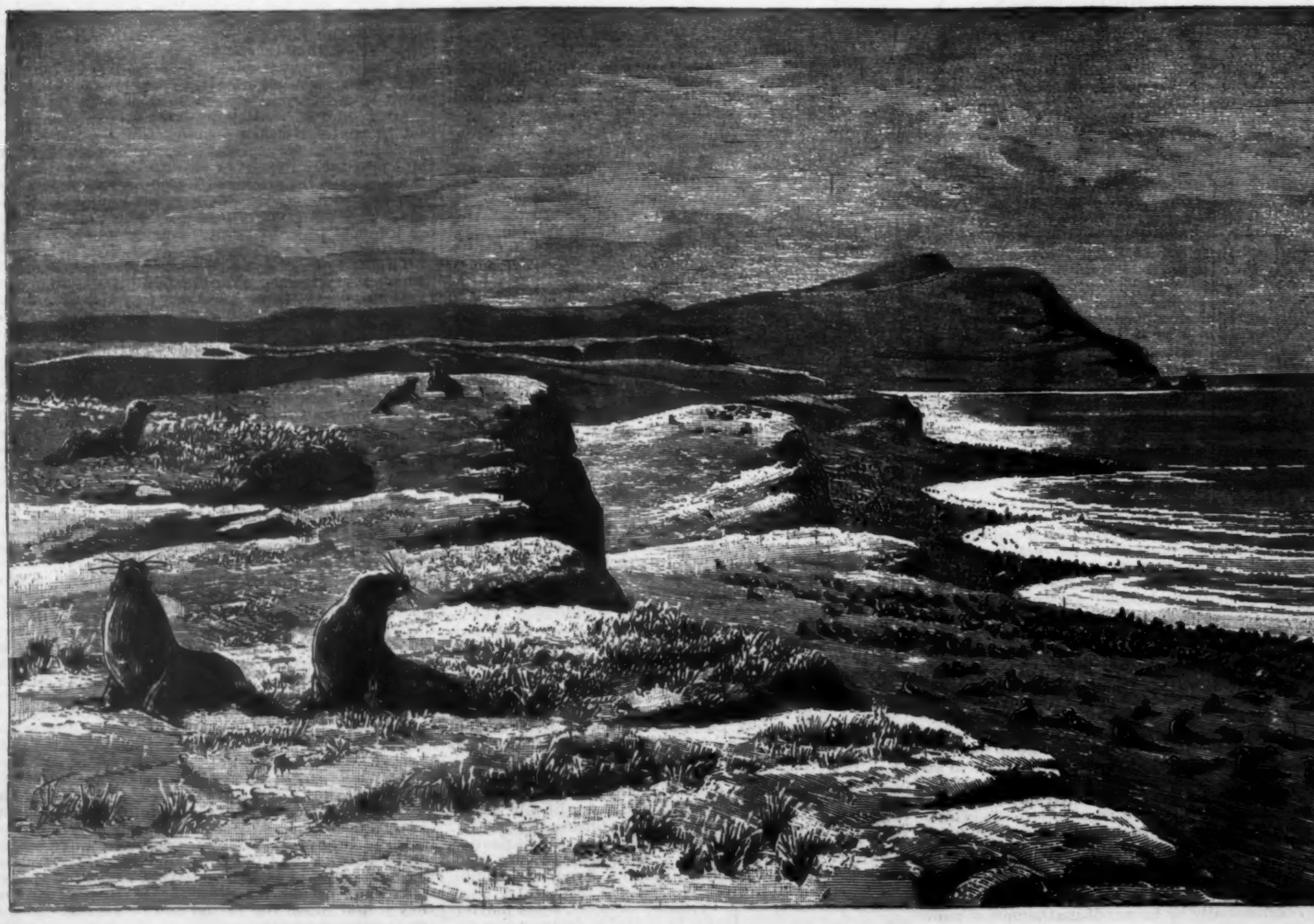
The largest flow in the State is at Larned. There a strong brine rushes to the surface with great force to a height of over fifteen fleet. It spouts forth from a depth of 430 feet and more, at the rate of from 250 to 300 gallons per minute. It is used for medicinal purposes and for swimming baths. A part of its waste may be seen from the railway in the form of a fountain more than ten feet high.

Wells at Coolidge nearly three hundred feet deep are obtaining from Dacotah sandstones a supply of good water, but slightly mineralized. The largest, yielding 100 gallons per minute, is utilized for the city water works. Others, giving out each about fifty gallons per minute, are used for irrigation and watering stock. There is one of small flow—six or eight gallons per minute—also used for irrigation.

* Read before the Kansas Academy of Science, Wichita, October, 1889.



ALASKA—DRIVING SEALS TO THE KILLING PLACE.



FUR SEAL ROOKERY IN THE PRIBYLOV ISLANDS, ALASKA.

In Meade County there is a group of wells in an area of several square miles that, at depths varying from fifty to one hundred and eighty feet, yield a good water, suitable for domestic purposes, in quantities varying from three or four gallons per minute to over sixty. The largest yield sixty-six gallons per minute, and on another farm there are three wells with an aggregate flow of ninety-eight gallons.

Some, but not nearly half, of the water of this district is used for irrigation, and two of the proprietors turn it into carp ponds. This water is obtained from debris of the Miocene grit, probably broken up in Pliocene time and covered by light blue impervious clay. The grit outcrops on the edges of neighboring high prairie; the wells are all in the valley, so the source and course of the water are easily determined.

The wells in Hamilton, Meade, and Pawnee Counties owe their waters and their force to the usual causes of artesian flowage. These are, the not very distant outcrop of porous strata catching the rainfall of a considerable area, the dip of these porous strata toward the wells and the overlying and underlying impervious beds of clay or clay shales. These conditions are illustrated in the diagram. The cause of the flow may be called hydrostatic pressure.

The artesian flow at Mound Valley in Labette County is a remarkable example of another force. The well was bored for gas or coal. Water was encountered at two places in the first hundred feet, and a small quantity of gas at 263 feet. At 277 feet there was a copious inflow of strong brine, which rose some distance in the tube. At 449 feet there came a flow of gas so powerful that it lifted the column of water to the surface and maintained it as a flowing well.

This example is a good one of gas pressure as an efficient cause of artesian flow. There are other wells in which this is a probable cause also, but not so certainly indicated as in this case. These might be called gas artesian, or in more direct reference to their cause, gas pressure wells.

There is, besides the true artesian wells and those which we have called "gas artesian," another class of wells which have the artesian flow, but which do not seem to be accounted for by the principles illustrated in either of those groups.

These wells have two characteristics in common—they are *deep* wells, and they have only a *small flow*. There are doubtless some others, but there are three which will serve to illustrate what we have to say. They are at St. Mary's and Wamego in Pottawotamie County, and at Richfield in Morton County.

They each have another quality in common, but this is also common to all deep wells, whether artesian or not, viz., the water is highly mineralized. That of the Pottawotamie wells is strongly saline, that of Richfield is without the salt, but has iron and other ingredients.

The artesian water at Wamego comes from a depth of 300 feet (289 to 304). That at St. Mary's, in the same well (there are several flows), is from depths of 454, 675, and 958 feet. That at Richfield is from a depth of just under 600 feet. The flow at Richfield is 6½ gallons per minute. The wells in Pottawotomie County have not had their flow measured, but no one of them exceeds that at Richfield; they appear to be much less.

In at least one of the St. Mary's wells there is a suspicion that gas may help to sustain the column of water, but there is no such appearance at Wamego, and at Richfield the case is the same.

The Pottawotamie wells are in Paleozoic (coal measure) strata. The Richfield well is in Mesozoic, the principal part being in Dacotah, and red beds (Triassic), with a little Tertiary at the top.

In neither of these cases do we have *apparent* the conditions of an ordinary artesian well. We have not seen an outcrop nor recognized a dip of strata that would point to the source of the flow, as in ordinary cases. Diligent inquiry has not revealed that other persons have recognized suitable outcrops.

The outcrop of the Paleozoic strata is to the east of St. Mary's, and there the surface of country is lower than in Pottawotamie County.

A possible outcrop for the Wamego sandstone horizon might be found in the highland south of the Kaw River and east of Topeka, but the St. Mary's wells give no water at that depth, and they are nearer that outcrop, though not in the exact line of the dip. The outcrop of the St. Mary's water horizons can only be found much farther east, where the surface is lower than at the wells. The outcrop of the Richfield water horizon must be looked for to the west.

The land is higher in that direction, but the outcrop of the horizon, which is here 600 feet deep, must be at a distance too great to warrant the looking to this outcrop as the source of the well.

It would seem then that in these wells of small output from considerable depths, some other than the usual causes of artesian flow must be looked for. We think that there is a cause ready to our hand sufficient for all such phenomena. It is always in operation, and might be expected sometimes to produce such results.

This cause we will call *rock pressure*. All rocks in the earth's crust contain some water. The more porous rocks contain the greater quantity. At a distance below the surface the superincumbent strata subject the rock masses to enormous pressure. If we assume that the rocks of Kansas, to a depth of 1,000 feet, have an average specific gravity three times as great as that of water, we are probably within bounds, as, though limestones and sandstones are usually somewhat less, the presence of iron in many of the beds will bring up the average considerably.

On this basis a prism of the rocks to the depth of 600 feet and 1 inch square would weigh 781 pounds, which is equivalent to a pressure of 52 atmospheres. If, then, 25 feet be taken as the measure of a column of these mineralized waters equivalent to 1 atmosphere, the rock pressure would be more than the equivalent of a column of water twice this height.

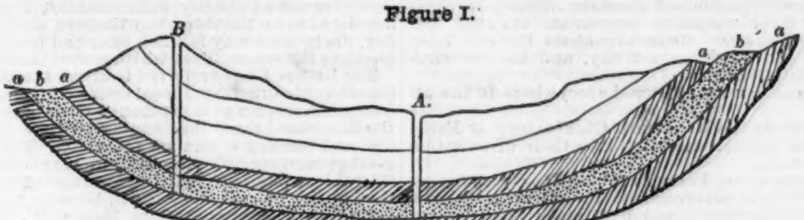
Let a water-bearing stratum at a depth of 600 feet, as at Richfield, be pierced by the drill, we should then have the rock pressure of 52 atmospheres squeezing the water out of the rock pores, and, granting sufficient plasticity in the rock and a sufficient quantity of water, it must rise in the tube which has only the pressure of 1 atmosphere upon it. A large bore to the well and a small supply of water would be against its reaching the surface.

On the other hand, a bed rock with mobile molecules at or near saturation, under this enormous pressure, must cause in a narrow tube a flowing well. At 300 feet the rock pressure would be only half that given above, or 26 atmospheres, and the column of water to be supported will be diminished in proportion. At other depths the same proportions will hold good.

Here, then, we have a force that may be merely an aid in some cases of artesian flow which is mainly due to the usual causes of such flow, and which is a most efficient cause for the constant flow of wells whose depth is great and whose quantity of water is small. We are inclined to consider rock pressure as the cause of the flow of the Pottawotamie and Morton County wells, at least till future search shall make more probable that it is due to the usual causes of artesian wells.

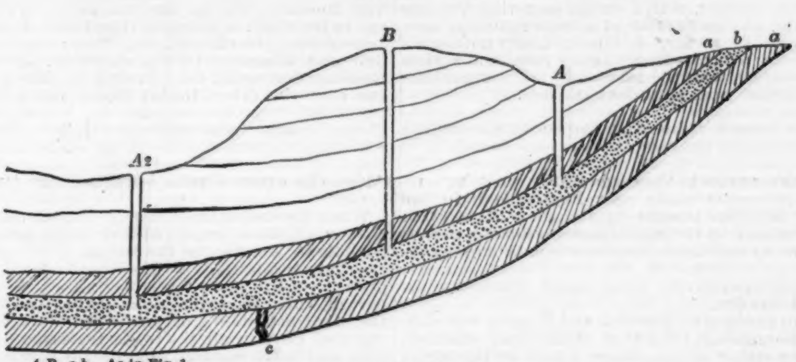
At some future time we may endeavor to classify all the artesian wells of Kansas with reference to the efficient causes of their flowage. At present we must be content with here suggesting the three forms of *hydrostatic*, *gas*, and *rock pressure* as these efficient causes, and especially to call attention to the last two in the cases of deep wells of small outflow.—*Amer. Geologist.*

Figure I.



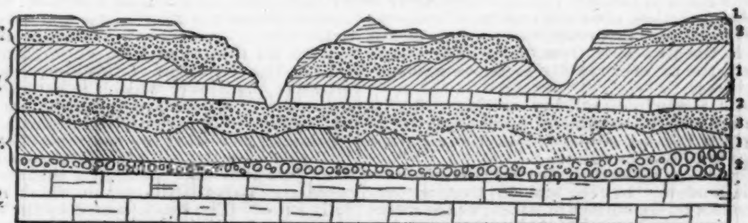
a. a. Impervious beds dipping towards center of basin, inclosing porous bed (*b*).
A. Well near center of basin with artesian flow.
B. Well on higher ground without artesian flow, because located higher than the outcrop of *b*.

Figure II.



A B. a b. As in Fig. 1.
c. Breach in the continuity of the lower (*a*) impervious bed.

Figure III.



T. Tertiary. *1.* Pliocene marl. *2.* Miocene grit.
C. Cretaceous. *1.* Niobrara. *2.* Benton. *3.* Dacotah.
Tr. Trias. *1.* Red Beds. *2.* Saliferous horizon.
P. Permo-carboniferous.

THE USUAL RELATIONS OF STRATA IN WESTERN KANSAS.

ATMOSPHERIC DUST.*

By Dr. WILLIAM MARCET, F.R.S.

THE infinitely small particles of matter we call *dust*, though possessed of a form and structure which escape the naked eye, play, as you are doubtless aware, important parts in the phenomena of nature.

A certain kind of dust has the power of decomposing organic bodies and bringing about in them definite changes known as putrefaction, while others exert a baneful influence on health, and act as a source of infectious diseases.

Again, from its lightness and extreme mobility, dust is a means of scattering solid matter over the earth. It may float in the atmosphere as mud does in water, and blown by the wind will perhaps travel thousands of miles before again alighting on the earth.

Thus Ehrenberg, in 1828, detected in the air of Berlin the presence of organisms belonging to African regions, and he found in the air of Portugal fragments of infusoriæ from the steppes of America.

The smoke of the burning of Chicago was, according to Mr. Clarence King (director of the United States Geological Survey), seen on the Pacific coast.

Dust is concerned in many interesting meterorological phenomena, such as fogs, as it is generally admitted that fogs are due to the deposit of moisture on atmospheric motes.

Again, the scattering of light depends on the presence of dust, and you may remember my showing you on a former occasion that beautiful experiment of Tyndall, illustrating the disappearance of a ray of light when made to travel through a glass receiver free from dust, while reappearing as soon as dust is admitted into the vessel.

There is no atmosphere without dust, although it varies largely in quantity, from the summit of the highest mountain, where the least is found, to the low plains, at the seaside level, where it occurs in the largest quantities.

The origin of dust may be looked upon, without exaggeration, as universal. Trees shed their bark and leaves, which are powdered in dry weather and carried about by ever-varying currents of air, plants dry up and crumble into dust, the skin of man and animal is constantly shedding a dusty material of a scaly form. The ground in dry weather, high roads under a midsummer's sun, emit clouds of dust consisting of very fine particles of earth. The fine river and desert sand, a species of dust, is silica ground down into a fine powder under the action of water.

If the vegetable and mineral world crumbles into *dust*, on the other hand it is highly probable that dust was the original state of matter before the earth and heavenly bodies were formed; and here we enter the region of theory and probabilities.

In a science like meteorology, where a wide door is open to speculation, we should avoid as much as possible stepping out of the track of known facts; still there is a limit to physical observation, and in some cases we can do no more than glance into the possible or probable source of natural phenomena.

Are we on this account to give up inquiring for *causes*?

This question I shall beg to leave you to decide, but where we have such an experienced authority as Norman Lockyer, I think the weight attached to possibilities and theories is sufficiently great to warrant my drawing your attention for a few moments to the probable origin of the stars and of our earth.

I dare say many of you have read the interesting article in the *Nineteenth Century* of November last, by Norman Lockyer, and entitled "The History of a Star." The author proposes to clear in our imagination a limited part of space, and then set possible causes to work; that dark void will sooner or later be filled with some form of matter so fine that it is impossible to give it a chemical name, but the matter will eventually condense into a kind of dust mixed with hydrogen gas, and constitute what we call nebulæ.

These nebulæ are found by spectrum analysis to be made up of known substances, which are magnesium, carbon, oxygen, iron, silicon, and sulphur.

Fortunately for persons interested in such inquiries, this dust comes down to us in a tangible form. Not only have we dust shed from the sky on the earth, but large masses, magnificent specimens of meteorites which have fallen from the heavens at different times, some of them weighing tons, may be submitted to examination. From the spectroscopic analysis of the dust of meteorites we find that in addition to hydrogen their chief constituents are magnesium, iron, silicon, oxygen, and sulphur.

There are swarms of dust traveling through space, and their motion may be gigantic. We know, for instance, some stars to be moving so quickly that, from Sir Robert Ball's calculations, one among them would travel from London to Pekin in something like two minutes.

From photographs taken of the stars and nebulæ, we are entitled to conclude that the swarms of dust meet and interlace each other, becoming raised from friction and collision to a very high temperature, and giving rise to what looks like a star. The light would last so long as the swarms collide, but would go out should

* An address delivered to the Royal Meteorological Society, January 15, 1890.

the collision fail; or, again, such a source of supply of heat may be withdrawn by the complete passage of one stream of dust swarms through another.

We shall, therefore, have various bodies in the heavens, suddenly or gradually increasing or decreasing in brightness, quite irregularly, unlike those other bodies where we get a periodical variation in consequence of the revolution of one of them round the other.

Hence, as Norman Lockyer expresses it clearly, "it cannot be too strongly insisted upon that the chief among the new ideas introduced by the recent work is that a great many stars are not stars like the sun, but simple collections of meteorites, the particles of which may be probably thirty, forty, or fifty miles apart."

The swarms of dust referred to above undergo condensation by attraction or gravitation; they will become hotter and brighter as their volume decreases, and we shall pass from the nebulæ to what we call true stars.

The author of the paper I am quoting from imagines such condensed masses of meteoric dust being pelted or bombarded by meteoric material, producing heat and light, which effect will continue so long as the pelting is kept up. To this circumstance is due the formation of stars like suns. Our earth originally belonged to that class of heavenly bodies, but from a subsequent process of cooling assumed its present character.

While apologizing for this digression into extra atmospheric dust, I shall propose to divide atmospheric dust into *organic* or *combustible* and *mineral* or *incombustible*.

The dust scattered everywhere in the atmosphere, and which is lighted up in a sunbeam, or a ray from the electric lamp, is of an organic nature. It is seen to consist of countless motes, rising, falling, or gyrating, although it is impossible to follow any of them with the eye for longer than a fraction of a second.

We conclude that their weight exceeds but very slightly that of the air, and, moreover, that the atmosphere is the seat of multitudes of minute currents, assuming all kinds of directions. Similar currents, though on a much larger scale, are also met with in the air. One day last June, from the top of Eiffel's tower in Paris, I amused myself throwing an unfolded newspaper over the rail carried around the summit of the tower.

At first it fell slowly, carried away by a light breeze, but presently it rose, and, describing a curve, began again to fall. As it was vanishing from sight, the paper seemed to me as if arrested now and then in its descent, perhaps undergoing again a slight upheaval.

Here was, indeed, a gigantic mote floating in the atmosphere, and subject to the same physical laws, though on a larger scale, as those delicate filaments of dust we see dancing merrily in a sunbeam.

I recollect witnessing at one of the Friday evening lectures of the Royal Institution, in the year 1870, the following beautiful experiment of Dr. Tyndall, illustrative of the properties of atmospheric dust: If we place the flame of a spirit lamp or a red hot metal ball in the track of a beam of light, there will be seen masses of dark shadows resembling smoke emitted in all directions from the source of heat. At first sight this appears as if due to the dust particles being burnt into smoke; but by substituting for the spirit flame or red hot metal ball an object heated to a temperature too low to burn the motes, the same appearance of smoke is observed. Hence the phenomenon is not owing to the combustion of the dust. The explanation, however, is obvious. The source of heat, by warming the air in its contact, and immediate proximity, made the air lighter and the motes relatively heavier; consequently they fell, and left spaces free from dust. These spaces in the track of the electric ray appeared dark, or looked as if full of a dense smoke, because the light of the ray could no longer be scattered in them from the absence of dust.

The motes were next examined by Tyndall, to determine whether they were organic or mineral. This was done by driving a slow current of air through a platinum tube heated to redness, and examining the air afterward in a beam of light; it was then found to darken the ray, having lost the power of scattering light; therefore the dust had been destroyed or burnt by passing through the red hot platinum tube, clearly showing its organic nature.

We breathe into our lungs day and night this very finely divided dust, and yet it produces no ill effect, no bronchial irritation. Tyndall has again shown by the analytical power of a ray of light what becomes of the motes we inhale.

Allow me to return to the experiment with the red hot metal ball placed in the beam of the electric light. Should a person breathe on the heated ball, the dark smoke hovering around it will at first disappear, but it will reappear in the last portions of the air expired. What does this mean?

It means that the first portions of air expired from the lungs contain the atmospheric motes inhaled, but that the last portions, after reaching the deepest recesses in the organs of respiration, have deposited there the dust they contained.

It is difficult to say how much of the dust present in the air may become a source of disease, and how much is innocuous.

Many of the motes belong to the class of *micro-organisms*, and the experiment to which we have just referred shows how easily these micro-organisms, or sources of infectious diseases, can reach the lungs and do mischief if they should find a condition of the body on which they are able to thrive and be reproduced. Atmospheric motes, although it has been shown that they are really deposited in the respiratory organs, do not accumulate in the lungs and air passages, but undergo decomposition and disappear in the circulation. Smoke, which is finely divided coal dust, is clearly subjected to such a destructive process; otherwise the smoky atmosphere of many of our towns would soon prove fatal, and tobacco smoke would leave a deposit interfering seriously after a very short time with the phenomena of respiration.

Dust, however, in its physical aspect is far from being always innocuous, and, as you are aware, many trades are liable to suffer from it.

The cutting of chaff, for horses' food, is one of the most pernicious occupations, as it generates clouds of dust of an essentially penetrating character. Those engaged in needle manufacture and steel grinders suffer much from the dust of metallic particles. Stone cutters, and workmen in plaster of Paris, coal heavers, cotton and hemp spinners, are also engaged in trades injurious to health, because of the dust these men unavoidably work in. Those engaged in cigar and rope manufactures, or in flour mills, hat and carpet manufacturers, are also liable to suffer for the same reason.

A number of methods have been adopted, more or less successfully, to rid these trades of the danger due to the presence of dust.

I shall not detain you on this subject, which would carry me too far, but merely bring to your notice the fact I observed many years ago, that charcoal has the power of retaining dust in a remarkable degree. I had charcoal respirators made of such a form as to cover both the mouth and nose, and containing about ½ inch thick of charcoal in a granular state.

I could breathe through such a respirator in the thickest cloud of dust made by chaff cutting without being conscious of inhaling any of the dust.

The subject of micro-organisms belongs to the science known as micro-biology. As meteorologists we are chiefly concerned with their distribution in the atmosphere.

Micro-organisms are dust-like particles capable of cultivation or reproduction in certain media and at certain temperatures. If a particle of matter known to contain micro-organisms, also called *bacilli*, be placed on a clear surface of gelatine and maintained at a temperature favorable to its development, in a short time the gelatine will be found to contain a colony of those same *bacilli*. A fact so often stated as to become a medical truism is that there can be no infectious disease without the presence of the micro-organism special to that disease.

Open cesspools, putrid meat or vegetable matter, accumulations of refuse, have no ill effects on health unless the micro-organisms of a certain disease, as those of typhoid fever or cholera, be present. On such foul decomposing matters these organisms thrive. They are reproduced with great activity, and become virulent in their effects.

Micro-organisms are scattered everywhere in the atmosphere.

Dr. Miguel, at the Montsouris Observatory at Paris, has made an extensive inquiry into their distribution in air and water.

In this country Dr. Percy Frankland has, with praiseworthy labor and perseverance, investigated the subject of micro-organisms, and ascertained their number in various localities. The result of his inquiry is that in cold weather, especially when the ground is covered with snow, the number of organisms in the air is very much reduced, and presents a very striking contrast with that found in warmer weather.

The experiments made on March 9 show that during cold and dry weather, with a strong east wind blowing over London, a large number of micro-organisms may still be present in the air. It is particularly noticeable that even after an exceedingly heavy rain, and within a few hours afterward, the number of micro-organisms in the air should be as abundant as usual.

Taking an average of the experiments made on the roof of the Science Schools of the South Kensington Museum, the mean number of organisms found in 10 liters of air amounted to 35, while an average of 279 fell on one square foot in one minute.

Other experiments made near Reigate and in the vicinity of Norwich present a marked contrast with those undertaken in the South Kensington Musuem.

There was a remarkable freedom from micro-organisms of the air collected on the heath near Norwich during the comparatively warm April weather, when the ground was dry.

The air in gardens at Norwich and Reigate was richer in micro-organisms than that of the open country. Again, the number of organisms found in the air of Kensington Gardens, Hyde Park, and Primrose Hill was less than in that taken from the roof of South Kensington, but greater than in the country.

Experiments made in inclosed places, where there is little or no aerial motion, show the number of suspended organisms to be very moderate, but as soon as any disturbance in the air occurs, from draughts or people moving about, the number rapidly increases and may become very great.

Experiments made in a railway carriage afford a striking example of the enormous number of micro-organisms which become suspended in the air when many persons are brought together.

Micro-organisms being slightly heavier than air, have an invariable tendency to fall, and on that account frequently collect on the surface of water; hence rivers, lakes, and ponds are constantly being thus contaminated. Micro-organisms in very pure water are not readily disposed to multiply, but traces of decomposing organic matter will induce their reproduction. One remarkable case occurs to me illustrating this fact. In 1884 a severe epidemic of typhoid fever broke out in the town of Geneva, in Switzerland. The water of the lake in the harbor, which is surrounded by houses on three sides, was then examined by a distinguished micro-biologist, M. Fol, who discovered it to be full of micro-organisms; the water supplied to the town for drinking purposes was taken from the River Rhone immediately as it flowed out of the harbor.

The inquiry was pursued further, and it was found that just outside of the harbor, on the surface of the water, there was still a number of micro-organisms, though less than in the harbor; but a few feet below the surface, say three or four feet, they had greatly diminished in number, indeed to such an extent that there were very few present. The obvious remedy was at once carried out.

A wooden aqueduct was constructed, opening into the lake about 150 yards outside the harbor, and some three or four feet under the surface.

As stated by Dr. Dunant, a Geneva physician, who has given a very interesting account of this epidemic,* eighteen days after the source of the water supply had thus been altered, a marked decline took place in the epidemic, and it was clearly being mastered. A similar epidemic due to a like cause occurred about the same time at Zurich.

There is one point connected with the properties of dust of organic origin which I think cannot fail to be of interest on the present occasion. It mean its inflammability, and its liability to explode when mixed with air. By *explosion* is meant that the propagation of flame by a very finely divided material, such as coal dust, mixed in due proportion with air, may proceed with a rapidity approaching the transmission of explosion by a gaseous mixture.

An interesting lecture was delivered on this subject at the Royal Institution in April, 1882, by Sir Frederick Abel, entitled "Some of the Dangerous Properties of Dust." The lecturer refers to instances of explosions in flour mills, due in all probability to a spark from the grinding millstones, occurring in consequence of a deficient supply of grain to the stones.

Messrs. Franklin and Macadam, who investigated the subject, found that accidents of this nature were of frequent occurrence. In May, 1878, a flour mill explosion, quite unparalleled for its destructive effects, occurred at Minneapolis, Minn. Eighteen lives were lost, and six distinct corn mills were destroyed. Persons who were near the scene of the calamity heard a succession of sharp hissing sounds, doubtless caused by the very rapid spread of flame through the dust-laden air of the passages inside the mill. The nearest mill to that first fired was twenty-five feet distance, and exploded as soon as the flames burst through the first mill. The explosion of the third mill, twenty-five feet from the second, followed almost immediately, and the other three mills, about 150 feet distance in another direction, were at once fired. The fire was attributed to a spark from friction of the millstones.

Coal dust in coal mines is a cause of accident from explosions, which has been closely investigated in this country, in Germany, and other mining districts. Sir Frederick Abel has given this subject especial attention, and brings it prominently forward in his valuable and exhaustive paper on "Accidents in Mines," read to the Institution of Civil Engineers in 1888. Some mines are, of course, more dusty than others, and coal dusts are not all equally inflammable. That which is deposited upon the sides, top timbers, and ledges in a dry, dusty mine way is much finer and more inflammable than the coarser dust which covers the floors.

The lecture I have referred to alludes to the case of a considerable quantity of coal dust accidentally thrown over some screens at a pit mouth busting into flame as the dust cloud came into contact with a neighboring fire, and burning a man very severely. There appears good ground for believing that fire may travel to a considerable extent through the workings of a mine from the ignition of coal dust, as will be seen in the following account, extracted from Messrs. W. W. & J. B. Atkinson's book on "Explosions in Mines:" "An appalling accident happened at the Seaham Colliery, in the County of Durham, on September 8, 1880, at 2.20 a. m., causing the death of twenty-four men. An explosion occurred in the mine, and a loud report was heard at the surface, accompanied with a cloud of dust from the shaft, but no fire was seen. Owing to damage to the shaft, it was more than twelve hours before a descent could be effected, and then a scene of destruction was witnessed by the explorers. Doors and air crossings destroyed, tubs broken to pieces and hurled one over the other, timber blown out, attended with heavy falls from the roof, and the bodies of men and horses in many cases terribly mutilated. The explosion was found to have extended over roads of an aggregate length of about 7,500 yards, the greatest distance between the extreme points reached being about 3,800 yards."

When discussing the cause of this terrible accident, Messrs. Atkinson remarked that it was apparently impossible to account for the effects of the explosion on the assumption that it was due to fire damp, as the presence of fire damp was most unlikely to occur at any part at which the explosion could have happened, and, therefore, attention must be turned to coal dust. There was coal dust on all the roads traversed by the explosion, and there was coal dust at the supposed point of origin. These facts are of striking significance. After the explosion, all parts of the mine in which its effects could be traced were covered on the bottom and on flat surfaces with a coating of fine dust, which, when examined under the microscope, appeared to have been acted on by great heat. This fine dust covered the surface for a depth of from one-eighth to one-half an inch and under. Dust of this kind was entirely absent on those roads over which the explosion had not extended. With reference to the original ignition, a shot had been fired apparently simultaneously with the explosion. The road at the place was of stone, and would probably be coated with the finest coal dust, and, moreover, just above the spot where the fatal shot was fired were large balks of timber, on which dust was plentifully stored. The shock caused by the explosion would throw the dust into the air, and the flame set fire to it. Thus initiated, the flame would extend through all the roads on which there was an uninterrupted supply of coal dust to support it.

The second part of this address relates to inorganic or mineral dust. When on the Peak of Teneriffe in 1878, engaged in a pursuit mostly of a physiological kind, I had occasion to use a very delicate chemical balance. My object was to determine the amount of aqueous vapor given out of the lungs while in the shallow crater at the summit of the peak, 12,200 feet above the sea. The heat was intense, as the sun shed its nearly vertical rays at midday on the fine white volcanic sand spread over the floor of the crater. At various places rocks projected, covered here and there with crystals of sulphur, and so hot that the hand could scarcely bear coming in contact with them. Anticipating some difficulty in the use of the balance from the action of the wind, I had brought up with me a hamper and a blanket. After placing the hamper sideways, with the lid off, I proceeded, though not without some little trouble, to dispose the balance satisfactorily inside the basket; then, having thrown the blanket over the hamper, I stretched out at full length on the burning sand, nestling under the blanket, much as a photographer would cover himself and camera with a dark cloth. On trying to use the balance it refused to act. Its beam would not oscillate. A careful examination showed the instrument to be apparently in perfect order, when it occurred to me to wipe the knife edges at the points of suspension of the beam and pans. The balance then worked quite well, though but for a few minutes only, again most provokingly declining to oscillate; indeed, it was only by constant wiping of the knife edges that I succeeded with my experiment. The cause of my trouble was clearly the presence of very fine mineral dust in the air, of which my senses were utterly unconscious. Hence it is that

* "Epidemie de fievre typhoide a Geneve en 1884," par P. L. Dunant, *Revue Medicale de la Suisse Romande*, 1887.

extremely fine particles of mineral dust may exist in the atmosphere, while escaping detection by our senses, and such an occurrence is probably more frequent than generally thought.

Prof. Piazzi Smyth, while on the Peak of Teneriffe, witnessed strata of dust rising to a height of nearly a mile, reaching out to the horizon in every direction, and so dense as to hide frequently the neighboring hills. The report of the Krakatao Commission of the Royal Society contains the following interesting account, p. 421 (Mr. Douglas Archibald's contribution to the report):

"In 1881 Prof. S. P. Langley ascended Mount Whitney, in Southern California, with an expedition from the Alleghany Observatory. At an altitude of 15,000 feet his view extended over one of the most barren regions in the world. Immediately at the foot of the mountain is the *Inyo Desert*, and in the east a range of mountains parallel to the Sierra Nevada, but only about 10,000 feet in height. From the valley the atmosphere had appeared beautifully clear, but, as stated in Prof. Langley's own words, 'from this aerial height we looked down upon what seemed a kind of level dust ocean, invisible from below, but whose depth was six or seven thousand feet, as the upper portion only of the opposite mountain range rose clearly out of it. The color of the light reflected to us from this dust ocean was clearly red, and it stretched in every direction as far as the eye could reach, although there was no special wind or local cause for it. It was evidently like the dust seen in midocean from the Peak of Teneriffe—something present all the time, and a permanent ingredient of the earthy atmosphere.'"

Dust Storms.—These storms, as suggested by Dr. Henry Cook, from whose paper to the *Quarterly Journal* of the Royal Meteorological Society, in 1880, I am now quoting, may be considered under three heads, according to their intensity—atmospheric dust, dust columns, and dust storms. Dr. Cook, alluding to occurrences in India, observes that there are some days on which, however hard and violently the wind may blow, little or no dust accompanies it, while on others every little puff of air or current of wind forms or carries with it clouds of dust. If the wind which raises the dust is strong, nothing will be visible at the distance of a few yards, the sun at noon being obscured. The dust penetrates everywhere and cannot be excluded from houses, boxes, and even watches, however carefully guarded. The individual particles of sand appear to be in such an electrical condition that they are ever ready to repel each other, and are, consequently, disturbed from their position and carried up into the air.

Dust columns are considered by Dr. Cook as due to electrical causes. On calm, quiet days, when hardly a breath of air is stirring, and the sun pours down its heated rays with full force, little eddies arise in the atmosphere near the surface of the ground. These increase in force and diameter, catching up and whirling round bits of sticks, grass, dust, and, lastly, sand, until a column is formed of great height and considerable diameter, which usually, after remaining stationary for some time, sweeps away across country at great speed. Ultimately it loses gradually the velocity of its circular movement and disappears. In the valley of Mingochar, which is only a few miles in width, and surrounded by high hills, Dr. Cook, on a day when not a breath of air stirred, counted upward of twenty of these columns. They seldom changed their places, and, when they did so, moved but slowly across the level tract. They never interfered with each other, and appeared to have an entirely independent existence.

Dr. Cook describes as follows a dust storm which took place at Jacobabad:

"The weather had been hot and oppressive, with little or no breeze, and a tendency for dust to accumulate in the atmosphere. On the evening of the storm heavy clouds gathered and covered the sky. About 9 p. m. the sky had cleared somewhat, and the moon shone. A breeze sprang up from the west, which increased and bore along with it light clouds of sand. At 9.30 p. m. the storm commenced in all its fury. Vast bodies of sand were drifted violently along. The stars and moon were totally obscured. It became pitch dark, and it was impossible to see the hand held close to the face. The wind blew furiously in gusts, and heaped the sand on the windward side of obstacles in its course. Lightning and thunder accompanied it, and were succeeded by heavy rain. The storm lasted about an hour, when the dust gradually subsided. The sky again became clear, and the moon shone brightly. The storm appeared to have entirely relieved the electrical condition of the atmosphere. A pleasant freshness followed, and the oppressive sensation before mentioned was no longer experienced. This, indeed, is the general effect of storms in Upper Scind. The air is cooled, the atmosphere cleared, and the dusty condition of the atmosphere which usually precedes them for several days completely disappears."

In the case of a memorable sand storm which occurred at Aden on July 16, 1878, and recorded by Lieut. Herbert Russell, there was a remarkable play of light on the objects which remained within sight. The sudden darkness from the storm gave a peculiar and ghastly tint to the white sand and neighboring plain, while the curling masses of sand drifted before the gale, resembling a dark yellow smoke. The varied lights quickly changing were curious and most grand, the sea a clear green, and Slave Island and Shum-Shum, usually of an arid brown color, became of an ashy white.

In a dust storm I experienced myself at Luxor, on the Nile, the suffocating effect of the sand as it drove into the lungs and air passages was very trying. People rushed to the immediate river side, where some relief was found.

A book on "Whirlwinds and Dust Storms in India," by P. L. H. Baddeley, surgeon, Bengal army, 1860, gives some interesting information on the electrical character of dust storms and dust pillars. When at Lahore, in 1847, this gentleman was desirous of experimenting on the electrical state of the atmosphere in a dust storm, and with this object he projected into the air, on the top of his house, an insulated copper wire fixed to a bamboo; the wire was brought through the roof into his room, and connected with a gold-leaf electrometer, a detached wire communicating with the earth. A day or two after, during the passage of a small dust storm, he observed the occurrence of vivid sparks from one wire to the other, and, of course, strongly affecting the electrometer. He subsequently witnessed at least sixty dust storms of various sizes, all presenting the same kind of phenomena.

Volcanic Dust.—This dust consists mainly of powdered vitrified substances, produced by the action of intense heat. It is interesting in many respects. The so-called ashes or scories shot out in a volcanic eruption are mostly pounded pumice, but they also originate from stones and fragments of rocks which, striking against each other, are reduced into powder or dust. Volcanic dust has a whitish-gray color, and is sometimes nearly quite white. Thus it is that, in summer, the terminal cone of the Peak of Teneriffe appears from a distance as if covered with snow; but there is no snow on the mountain at that season of the year. The white cap on the peak is entirely due to pumice ejected centuries ago. It is probably to this circumstance that the island and peak owe their name, as in the Guelph language the words *Tener Ifa* mean *white mountain.*

The friction caused by volcanic stones and rocks as they are crushed in their collision develops a mass of electricity which shows itself in brilliant displays of branch lightning darting from the edges of the dense ascending column. During the great eruption of Vesuvius, in 1822, they were continually visible, and added much to the grandeur of the spectacle. It not unfrequently happens that dust emitted from Vesuvius falls into the streets of Naples; but this is nothing in comparison with the mass of finely powdered material which covered and buried the towns of Pompeii, Herculaneum, and Stabiæ in the year 79.

On this occasion, according to the younger Pliny, total darkness from the clouds of volcanic ashes continued for three days, during which time ashes fell like a mantle of snow all over the surrounding country. When the darkness cleared away, the calamity was revealed in all its awful extent, the three towns having disappeared under the showers of dust.

The eruption of Krakatao, a mountain situated on an island in the Straits of Sunda, exceeded, in all probability, in its deadly effects, and as a wonderful phenomenon of nature, the outburst of Vesuvius in the year 69. The Krakatao Committee of the Royal Society have collected and published in their interesting report particulars of that memorable eruption, all of them thoroughly authenticated and reliable. The following is extracted from a communication to the report by Prof. Judd:

"On August 26, 1883, it was evident that the long continued moderate eruptions of Krakatao had passed into the paroxysmal stage. That day, about 1 p. m., the detonations caused by the explosive action attained such a violence as to be heard at Batavia and Buitzenborg, about one hundred English miles away. At 2 p. m. Captain Thompson, of the Medea, then sailing at a point seventy-six miles east-northeast of Krakatao, saw a black mass like smoke rising into the clouds to an altitude which has been estimated at no less than seventeen miles (nearly six times the height of Mont Blanc)."

If this surmise be correct, some idea of the violence of the outburst can be formed from the fact that during the eruption of Vesuvius in 1872 the column of steam and dust was propelled to a height of from four to five miles only.

At 3 p. m. the explosions were loud enough to be heard one hundred and fifty miles away. At Batavia and Buitzenborg the noise is described as being like the discharge of artillery close at hand. Windows rattled, pictures shook, but there was nothing in the nature of earthquake shocks—only strong air vibrations.

Captain Wooldridge, of the Sir R. Sale, viewing the volcano at sunset on the 26th, describes the sky as presenting a most terrible appearance, the dense mass of cloud of a murky tinge being rent with fierce flashes of lightning. At 7 p. m., when from the vapor and dust clouds intense darkness prevailed, the whole scene was lighted up by electrical discharges, and at one time the cloud above the mountain presented the appearance of an immense pine tree, with the stem and branches formed of volcanic lightning. The air was loaded with excessively fine ashes, and there was a strong sulphurous smell. The steamer G. G. Loudon, within twenty or thirty miles of the eruption, passed through a rain of ashes and small bits of stone.

Captain Watson, of the ship Charles Bal, at a spot about a dozen miles off the island, records the phenomena of chains of fire appearing to ascend between the volcano and the sky, while on the south side there seemed to be a "continual roll of balls of white fire." These appearances were doubtless caused by the discharge of white hot fragments of lava rolling down the sides of the mountain. From midnight till 4 a. m. explosions continually took place, the sky one second being intense blackness, the next a blaze of fire.

All the eye witnesses agree as to the splendor of the electrical phenomena. Captain Wooldridge, viewing the eruption from a distance of 40 miles, speaks of the great vapor cloud resembling an immense wall, with outbursts of fork lightning, like large luminous serpents, rushing through the air. After sunset this dark wall assumed the appearance of a blood red curtain, with the edges of all the shades of yellow—the whole of a murky tinge, and attended with fierce flashes of lightning. It was reported from the Loudon that lightning struck the mast head conductor five or six times and that the mud rain which covered the masts, rigging, and decks was phosphorescent. The rigging presented the appearance of St. Elmo's fire, which the native sailors were busily engaged putting out with their hands, alleging that, if any portion found its way below, a hole would burst in the ship; not that they feared the ship taking fire, but they thought the light was the work of evil spirits, and that if it penetrated the hold of the vessel, the evil spirits would triumph in their design to scuttle the ship.

By these grand explosive outbursts the old crater of Krakatao was completely eviscerated, and a cavity formed more than 1,000 feet in depth; while the solid materials thrown out from the crater were spread over the flanks of the volcano, forming considerable alterations in their forms.

The sea disturbance which accompanied the eruption of Krakatao was carefully investigated by Captain Wharton, hydrographer to the Admiralty: "The rush of the great sea wave over the land, caused by the violent abrasion in the crater, aided by the action on the water of enormous masses of fallen material, caused great destruction of life and property in the Straits of Sunda. By the inrush of these waves on land, all vessels near the shore were stranded, the towns and villages near the coast devastated, two of the lighthouses were swept away, and the lives of 36,380 of the inhabitants sacrificed. It was estimated that the wave was about 50 feet in height when it broke on the shore."

On the morning of the 27th, between 10 and 11 a.m., three vessels at the eastern entrance of the Straits encountered the fall of mingled dust and water, which soon darkened the air and covered their decks and sails with a thick coating of mud. Some of the pieces of pumice falling on the Sir R. Sale were said to have been of the size of a pumpkin. All day on the 27th, the three vessels were beating about in darkness, pumice dust falling upon them in such quantities as to employ the crew for hours in shoveling it from the decks and in beating it from the sails and rigging. At Batavia, 100 miles from Krakatao, the sky was clear at 7 a. m., but at 11 a. m. there fell a regular dust rain; at 11.20 complete darkness pervaded the city. The rain of dust continued till 1, and afterward less heavily till 3 p. m.

The speed and distance attained by the pumice ejected from the volcano may be conceived from the fact stated in Mr. Douglas Archibald's contribution to the report, that dust fell on September 8, more than 3,700 English miles from the seat of the eruption.

The great mass of pumice thrown out during the eruption presented a dirty grayish white tint, being very irregular in size. It was undoubtedly due to the collision of fragments of pumice as they were violently ejected from the crater; the noise produced was even more striking than the sound of the explosion.

The dust ejected from Krakatao did not all fall back at the same time upon the sea and earth; as the lightest portions formed into a haze, which was propagated mostly westward. Mr. Archibald states in the report that most observers agree upon considering this haze as the proximate cause of the twilight glows, colored suns, and large corona, which were seen for a considerable time after the eruption. The haze was densest in the Indian ocean and along the equatorial belt, and was often thick enough to hide the sun entirely when within a few degrees from the horizon.

And now, ladies and gentlemen, I must bring this address to a conclusion, and thank you for having followed me over a long dusty track. I hope I have succeeded in showing that infinitely small objects, no larger than particles of dust, act important parts in the physical phenomena of nature, just as small and apparently unimportant events occasionally lead to others of the greatest magnitude.

A PROCESS FOR DECOMPOSING COMMERCIAL NICKEL AND ITS SALTS AND GALVANICALLY COATING OBJECTS WITH PURE NICKEL.

By Prof. GERHARD KRUSS, Lecturer at the University of Munich.

ACCORDING to experiments, made by the author, metallic nickel, regardless of the known technical impurities contained therein, for instance, iron, copper, arsenic, manganese, silicium, etc., is not a chemical element, but an alloy. This alloy contains averagely about 98 per cent. of a metal similar indeed in its properties to the substance hitherto named "nickel," but finer in various respects, which metal I will designate with "Ni," and about 2 per cent. of an element considerably differing from nickel in its properties and in the nature of its compounds. This element shall for the present be designated with "X."

Ni, free from X, that is to say, nickel in the new sense of the word, is produced from common nickel, nickel salts, or direct from the solutions of the raw materials obtained by concentration smelting, by proceeding according to the different nature of these elements. It is impossible to separate pure Ni by one operation from the said alloy of Ni and X, very rich in Ni, as the combinations of X also if insoluble in the residue of their precipitant, are soluble in Ni salts, therefore resist separation from the latter. It is therefore necessary to repeat one of the hereafter mentioned operations several times, or preferably several of these operations are successively performed to obtain pure nickel. Said operations are derived from the following peculiar properties of the compounds of the element X.

The neutral chloride, which is colorless—

(1) When treated with concentrated alkali lyes or melted with caustic alkali, is not changed into a hydroxide insoluble in water, but any hydroxide produced is wholly or partly converted into a combination of alkali soluble in water. The snow white hydroxide precipitated by means of common alkali lye, for instance ¼ normal solution, is, however, very little soluble in the latter, also with the addition of a large residue of the precipitant.

(2) Is but incompletely precipitated in solution through oxalic acid at a low as well as at a high temperature, more completely, however, through oxalate of ammonium, even at a low temperature after short standing. A very great residue of the latter precipitant can return the precipitant into solution.

(3) Is not precipitated in solution through fixed alkali lyes or ammonia, oxalate of ammonium or oxalic acid, even at a high temperature, if the solution has been previously acidified by the addition of organic acids, for instance, acetic acid, citric acid, pyrotartaric acid, etc.; whereas the soluble double oxalates of Ni are decomposed, on heating their solution, by one of the said acids, and deposit insoluble oxalate of nickel. If the combinations of the element X are, in solution or otherwise, brought in contact with a metal which is more electro-positive than Ni, for instance, with zinc, the compounds are not reduced even by short heating.

All these properties inherent on the pure X-compounds are to a different extent or completely altered and concealed if a solution contains besides X-salts also combinations of Ni. This is the case in the nickel salt solutions of former designation. The white hydroxide of X, for instance, is not at all precipitated by ammonia, if, in a nickel salt solution of former designation,

more than 70 per cent. of the dissolved substance consists of Ni salt.

If the nickel raw materials obtained by concentration smelting contain mixtures rich in X, of Ni and X, or of their salts, or solutions rich in X, of commercial nickel or commercial nickel salts, the neutral solutions to separate the Ni from the X are mixed with ammoniacal oxalate of ammonium, till the precipitate produced is redissolved. Subsequently they are allowed to stand for some time, white basic oxalate of X being thereby precipitated, and some more ammoniacal oxalate of ammonium is added. This addition is repeated until, after some longer standing, the quantity of the white precipitate ceases to increase. The blue liquid above the precipitate having been evaporated, its residue is thoroughly glowed and then mixed with such a quantity of muriatic acid as is required for solution. The solution of chloride is subsequently concentrated, and while heating it, solid hydrate of soda, up to five times the weight of the chloride, is incorporated therein, the doughy mass thereby produced being kept melting for a short time. The molten mass when cooled is broken up and brought in small pieces into ice cold water, care being taken, if necessary by the addition of ice, to prevent the temperature of the liquid from rising above 10° C. Thereby the natrium compound of the oxide of X is dissolved, while rather pure hydroxide of Ni remains undissolved. The alkaline liquid containing X having been poured or drawn off after some standing, the hydroxide of Ni is washed by decantation and dissolved in weak mineral acids or in acetic acid. This solution is mixed with such organic acids as are also capable of preventing the aluminum from being precipitated through alkalies, for instance, with acetic acid, pyrotartaric acid, or citric acid. On adding soda lye to the liquid thus obtained, while heating, pure hydroxide of Ni, free from X, is precipitated; or pure oxalate of Ni, free from X, can be produced in boiling heat by precipitating the said solution of nickel, acidified with an organic acid, with soluble oxalates, for instance, oxalate of ammonium, all X being thus kept in solution, as by the preceding operations the greater part of X has already been eliminated from the commercial nickel or its salts.

In lieu of this, however, also the solutions of commercial nickel, of its salts, or of the nickel raw materials obtained by concentration smelting, and the nickel compounds produced by the above treatment may be decomposed into pure nickel (Ni) or its salts and the element X or its compounds respectively, by bringing the nickel compounds or solutions referred to in contact with a metal which is more electro-positive than the Ni metal itself.

Nickel salts are in this manner more easily reducible, and, for instance, a solution of sulphate of nickel, chloride of nickel, or nitrate of nickel is soon almost completely decolored when warming it with zinc dust or fine zinc chips, nickel metal being precipitated and zinc brought in solution as sulphate. The compounds of X are thus not reduced and remain in solution.

If the neutral or weak acid solutions of the nickel raw materials, obtained by concentration smelting, or like solutions of commercial nickel or nickel salts contain but few X compounds, pure nickel can be obtained from them by performing once or twice one of the two last described operations.

The pure nickel obtained by the above described process is particularly adapted for galvanically coating objects. While the nickel obtained by the processes already known has a br wnish yellowish hue, owing to the metal hereinbefore named X, inherent thereto, the color of pure nickel (Ni), if not perfectly free from a yellowish shade, is decidedly more like silver and lighter, its application consequently preferable to the galvanic nickeling heretofore in use. To this end, any of the known processes may be applied by using nickel salts free from X for producing the alkaline neutral or acid nickel baths, and as nickel anodes such of nickel free from the element X, or from its oxide.

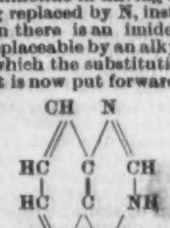
Having now particularly described and ascertained the nature of this invention, and in what manner the same is to be performed, I declare that what I claim is:

(1) The process for decomposing commercial nickel and its salts into pure nickel (Ni) or into pure nickel salts and into an element, designated with "X" in the specification, or its salts, that is to say, the process for producing such metals (Ni and X) and their compounds, substantially as described.

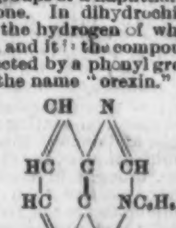
(2) The application of nickel, free from the element designated with X in the specification, or of the salts of such nickel for galvanically coating objects.—*Chem. News.*

OREXIN.

ANOTHER complex chemical compound has during the past month made its appearance as a candidate for a place in the materia medica, the claim of the new comer, for a wonder, not being that it is an antipyretic or an analgesic, but a stomachic and appetite producer, for which reason it has been named "orexin." As there are signs that the virtues of this compound will not be hidden under a bushel, some information as to its nature may be useful in the event of interest in it being aroused. Orexin is one of a series of compounds recently prepared synthetically by Messrs. Paul & Busch (*Berichte*, xxii., 2683). It is described as being a derivative from chinazolin, a term applied to a compound represented by a structural formula differing from that of chinoline in having two CH groups of a naphthalene ring replaced by N, instead of one. In dihydrochinazolin there is an imide group, the hydrogen of which is replaceable by an alkyl group, and it is the compound in which the substitution is effected by a phenyl group that is now put forward under the name "orexin."



Dihydrochinazolin.



Phenyldihydrochinazolin or orexin.

In practice this compound is manufactured by heating the sodium compound of formanilid with the corresponding quantity of o-nitrobenzylchloride, and after purification of the resulting o-nitrobenzylformanilid reducing it to phenyldihydrochinazolin by means of zinc dust in acetic solution. The hydrochloride of this base—orexine hydrochloride—with which the clinical experiments appear to have been made, is stated to be produced in needles containing two equivalents of water of crystallization, which is gradually given off in an exsiccator, the crystals becoming efflorescent: the melting point of the hydrated crystals is 80° C., that of the anhydrous 221°. When laid upon the tongue the compound tastes slightly bitter and leaves an intense burning sensation; it also irritates powerfully the mucous membrane of the nose. In ether it is insoluble, but it is readily soluble in hot water and in alcohol, and for this reason the hydrochloride is preferable in dispensing to the free base, which is almost insoluble in water. From an aqueous solution of the hydrochloride the base is separated by alkalies as an oily precipitate that afterward crystallizes. Orexin hydrochloride is reported to have been used by Prof. Penzoldt in thirty-six clinical cases, in most of which appetite is said to have been induced and the digestion stimulated. In the case of healthy persons the appetite is stated to increase immediately after the first dose, but with most patients the improvement is manifest only after some days. The formula recommended for administration is 2 grammes of orexin hydrochloride made up with extract of gentian and althea powder into twenty pills, gelatin coated, three to five of which are to be taken once or twice daily with a large glassful of meat broth, a considerable quantity of liquid being required on account of the pungent properties of the compound.—*Pharm. Jour.*

LIQUID MASSES.—Herr W. Spring has found that the free surface of a liquid is chemically more active than its internal mass. To show this, he puts into dilute hydrochloric acid a slab of marble slightly thickened at its upper end, so as to form a resting place for bubbles. Where the bubbles gather, the marble is very rapidly eaten through. So also on blowing air on any spot, and so on putting a slab partly within and partly outside the liquid.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. CHEMISTRY.—A Process for Decomposing Commercial Nickel and its Salts and Galvanically Coating Objects with Pure Nickel.—By Prof. GERHARD KRUSS.—A curious paper, treating nickel as an alloy containing two per cent. of an unknown metal 12069

II. CIVIL ENGINEERING.—The New York and Long Island Tunnel.—Contemplated tunnel across the city of New York, its construction and general connections.—3 illustrations 12057

III. ELECTRICITY.—Electrical Works at Spokane Falls.—Description and view of a Western electric station.—1 illustration 12062

IV. IRRIGATION.—Artesian Wells in Kansas and Causes of their Flow.—By ROBERT HAY.—A review of the Kansas wells, being an interesting contribution to the geology of irrigation.—3 illustrations 12066

V. MEDICINE AND HYGIENE.—Orexin.—A new medicine, a stomachic and appetite producer: its formula and properties 12070
The Action of Caffeine on the Motor and Respiratory Functions in the Normal State and in Inanition.—By MM. GERMAIN SEE and LAPICQUE.—A very remarkable paper showing the beneficial effects of the alkaloid properly administered 12062

VI. MISCELLANEOUS.—African Insect Wax.—A new wax from Damaraland.—Its use by the Zulus in their toilet.—1 illustration .. 12064
The Bridge of Matches.—A most interesting example of a simple mechanical experiment.—3 illustrations 12065
The Alaska Seal Industry.—The slaughter of seals.—Incidents of the attack.—Curious illustrations of a seal drive and of a seal rookery.—1 illustration 12066

VII. METEOROLOGY.—Atmospheric Dust.—By Dr. WILLIAM MARCET.—A very exhaustive and valuable paper on cosmic and atmospheric dust 12067

VIII. NAVAL ENGINEERING.—H. M. S. Latona.—A recent addition to the British navy.—A new protected cruiser.—1 illustration 12055
The Marine Locomotive.—A proposed locomotive for use on water, floating upon its own paddle wheels.—8 illustrations 12056

IX. ORDNANCE.—Modern Gunpowder as a Propellant.—By Major F. W. J. BARKER.—An exceedingly elaborate paper on the subject of modern powder, its composition, and other features.—6 illustrations 12059
The Gun Factory of the Forges et Chantiers, at Havre.—The manufacture of great guns in France.—The turning of a 100-ton piece.—2 illustrations 12059

X. PHYSICS.—Scientific Opportunities.—By Prof. OLIVER LODGE.—A most suggestive paper, giving clews to lines of physical work. . 12065